BYTE

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AUGUST 1985 VOL. 10, NO. 8

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THE AMIGA from Commodore

DECLARATIVE LANGUAGES:
Prolog, Hope, FP

No matter what b
you're in

Candidate Search Update

FILE: *Resumes*
SEARCH DATE: *5/20/85*
CLIENT: *Splendora Gourmet Baby Foods*

FIND

EXPERIENCE = *Marketing Manager*
FIELD = *Foods/Infant*
SIZE = *500+ Employees*
SALARY REQ.= *$40-$50,000 Per Annum*
LOCATION REQ.= *Detroit*
-or-
RELOCATABLE = *Yes*

Name	Experience	Salary	Education	Age
Antosz, Hank	1978—Present Pinz-Pinz Baby Food 1976—1978 Heath Baby Products	$45,000	Harvard MBA/Mktg.	33
Brown, Bob	1984—Present Liz for Kids 1982—1984 Bonnie Babe, Inc.	$48,000	CSUN/Marketing BA	26
Hayden, Steve	1979—Present Heath Baby Products 1975—1979 Nummy Tummies	$43,000	UCLA/Sociology BA Harvard MBA	35
Morrison, John	1977—Present Camille Grocers, Ltd. 1974—1977 Georgie Porgie of London	$40,000	Oxford/Marketing	32
West, Nick	1961—Present Bonnie Babe, Inc.	$47,000	UCLA MBA/Mktg.	42



May 20, 1985

Mr. Greg Helm
Vice President, Marketing
Splendora Gourmet Baby Foods
2200 Michigan Place East
Winnetka, Illinois

Dear Mr. Helm:

As a busy executive you know that accomplishing your many professional objectives is a full-time job.

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1981 1982 1983 1984

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Sincerely,

Cynthia Shern

Cynthia Shern
Senior Associate

CS:dh

enc.

Personality

Leadership

Experience

Communication

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Candidate Profile Analysis

Candidate 1
Candidate 2
Candidate 3
Candidate 4
Candidate 5

Each graph represents seven to ten pages of test information per candidate.

Individual tests are available for your review at your request.

As these comparative charts indicate, all candidates tested competitively in the four areas.

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Recruit-A-Suit Income Statement
Fiscal Year Ending 9/30/84

	Q1	Q2	Q3	Q4	Year-end
SALES					
Ann Arbor					
Fees	20,000	19,000	22,000	17,000	78,000
Commissions	52,000	45,000	48,000	42,000	187,000
Total Ann Arbor	72,000	64,000	70,000	59,000	265,000
Detroit					
Fees	44,000	46,000	42,000	39,000	171,000
Commissions	68,000	72,000	64,000	62,000	266,000
Total Detroit	112,000	118,000	106,000	101,000	437,000
TOTAL SALES	184,000	182,000	176,000	160,000	702,000
OPERATING EXPENSES					
Ann Arbor					
Payroll	30,000	30,000	33,000	30,000	123,000
Taxes	2,500	2,500	2,600	2,500	10,100
Auto	1,200	1,200	1,200	1,200	4,800
Telephone	600	600	600	600	2,400
Rent	8,000	8,000	8,000	8,000	32,000
Utilities	500	500	500	500	2,000
Dues/Subscrip.	100	100	200	100	500
Advertising	3,000	3,000	4,000	4,000	14,000
Travel	1,000	1,000	1,000	1,000	4,000
Entertainment	1,500	1,500	1,750	1,500	6,250
Office Supplies	300	300	300	300	1,200
Ann Arbor Total	48,700	48,700	53,150	49,700	200,250
Detroit					
Payroll	50,000	52,000	50,000	50,000	202,000
Taxes	4,200	4,400	4,200	4,200	17,000
Auto	2,400	2,400	2,400	2,400	9,600
Telephone	1,200	1,500	1,500	1,200	5,400
Rent	9,100	9,100	9,100	9,400	36,700
Utilities	800	800	800	800	3,200
Dues/Subscrip.	200	250	200	200	850
Advertising	3,000	3,500	3,500	3,000	13,000
Travel	1,200	1,500	1,200	1,400	5,300
Entertainment	1,600	1,800	1,600	1,400	6,400
Office Supplies	400	400	400	400	1600
Detroit Total	74,100	77,650	74,900	74,400	301,050
E XPENSES TOTAL	122,800	126,350	128,050	124,100	501,300
NET PRE-TAX PROFIT	61,200	55,650	47,950	35,900	200,700

If a picture is worth a thousand words, business graphics like these could cut meetings and presentations in half. We've taken information on five candidates stored in one software program, copied it into another program, where it was used to create these comparative bar graphs. Once your data is entered, this particular software program gives you your choice of 42 different graph configurations. You can preview your material (whether it's candidates, costs or cookies) in each configuration to decide which chart or graph most persuasively makes your point.

*As you well know, business involves innumerable number-related tasks, not the least of which is generating income and expense statements like this one. Should you want to change any of the entered items—to take a look at the effects of opening a new office or decreasing your staff—a spreadsheet program like Multiplan** will automatically recalculate the entire document. (Here, we've copied it into MacDraw™ and enhanced it for presentation purposes.) It not only saves hours of entering, double-checking and erasing, but when teamed up with our LaserWriter printer, it produces a printout impressive enough to show a bank president. Fast enough for this afternoon's meeting.*

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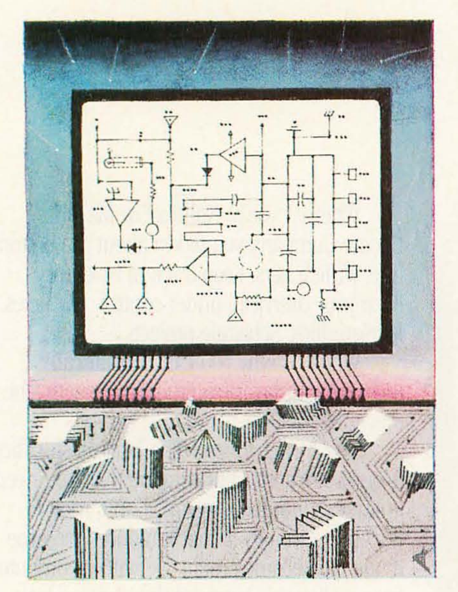
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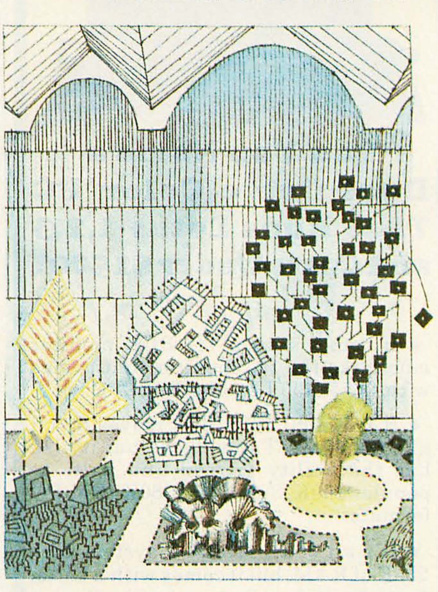
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BYTE August

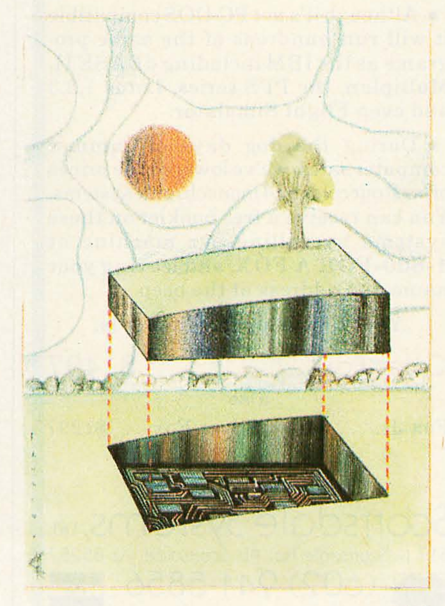
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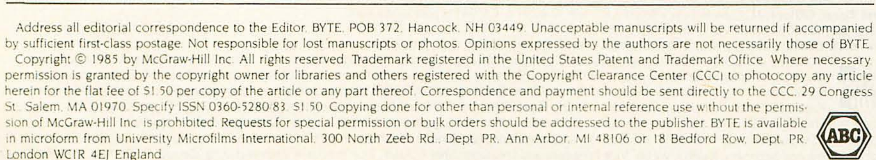


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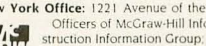
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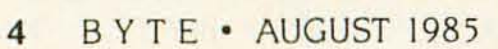
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E·D·I·T·O·R·I·A·L

A Very Special Issue

BYTE's readers like to stay on the leading edge of technology and to try things for themselves. We think this issue offers extraordinary opportunities for you to discover some of the most exciting developments at the forefront of personal computing. The new Amiga personal computer from Commodore International is a machine to rekindle the enthusiasm that drives personal computing.

Gregg Williams, Jon Edwards, and Phil Robinson have explained the Amiga's architecture in fascinating detail. The Amiga's custom coprocessors for the 68000 bring high performance. Dazzling graphics and audio and an open expansion bus make the Amiga the intellectual and technical heir to the Apple II. The Amiga's operating system is a full-color, icon-based windowing system with true concurrency. All the dazzle does nothing to inhibit the Amiga's performance in any serious application.

The Amiga's price seems fair, too. With the 68000, three custom chips that control graphics, audio, and peripherals, voice synthesis hardware with software to drive it, 256K bytes of RAM, 192K bytes of ROM, and input/output that includes an 800K-byte microfloppy, RGB analog, RGB digital, NTSC composite, two stereo jacks, a mouse, a parallel port, a high-speed serial port, and a disk port, plus the expansion bus, BASIC, a word processor, a paint program, and four other pieces of bundled software, the Amiga retails for $1295. Add Tecmar's $995 hard disk and an RGB monitor, and you have a phenomenal computer system.

This issue also offers readers an opportunity to build a true 32-bit computer system. Based on National Semiconductor's 32032, the Definicon DSI-32 coprocessor board for the IBM PC also uses the NS32081 floating-point chip and has the NS32082 memory-management chip as an option. FORTRAN, Pascal, C, and other languages are available. If you have an IBM PC with 15 watts of power to spare, the DSI-32 can move you a generation ahead in computing power. Phil Robinson was instrumental in bringing this exciting project to the pages of BYTE.

Steve Ciarcia, preparing the blockbuster Circuit Cellar SB180 computer for September's 10th Anniversary issue, gives us the versatile and powerful BASIC-52 computer/controller (BCC-52) this month. Programmable in a ROM-based BASIC, the BASIC-52 and its on-board language are ideal for process control and are bus-compatible with Steve's earlier Z8 controllers. The BCC-52 board utilizes the Intel 8052AH-BASIC microcontroller chip and includes 48K bytes of RAM/EPROM, an EPROM programmer, three parallel ports, a serial terminal port, and a serial printer port.

Jonathan Amsterdam's Programming Project shows how to parse integer arithmetic expressions into executable form. This software project is written in Pascal for the Apple II, but Jonathan has taken care to write portable code. He has also explained the roots of the project in linguists' work on context-free grammars. The article goes from theory of context-free grammers to a working Pascal version of a Texas Instruments–style four-function integer calculator. We'll be having at least one Programming Project in the feature section each month.

Leading-Edge Software

The feature section emphasizes hardware in part because the theme section is devoted to declarative programming languages. Declarative languages are gaining popularity because they are ideal for parallel processing and because their proponents claim they will increase the productivity of programmers.

Thanks to contributions from a variety of authors, including several at the Imperial College of Science and Technology in London, England, this language issue gives readers insights into relational languages such as Prolog and functional languages such as Hope and FP. (There is little on LISP because of a previous theme issue on LISP and additional LISP articles in the April 1985 issue.) Special thanks go to Susan Eisenbach of Imperial College and Tom Clune of the BYTE staff for putting this theme section together.

Susan Eisenbach and Chris Sadler give an overview of declarative languages. Robert Kowalski, one of the pioneers of Prolog, explains logic programming as a form of processing that is congenial to human thinking and also easy to implement on a computer. Clara and John Cuadrado tell who is using Prolog where and for what. John Darlington gives an excellent account of the power that declarative languages gain from their "referential transparency"—the fact that the meaning of a program fragment depends only on the meanings of its components, not on the history of any computation done before the evaluation of the fragment. Darlington provides examples written in Hope. Peter Harrison and Hessam Khoshnevisan give us a look at John Backus's functional programming language, FP, which builds variable-free programs from a set of primitive programs by use of program-forming operations and recursive definitions.

Finally, Roger Bailey gives a lucid tutorial in the use of Hope that should bring you into the world of declarative languages. Although he didn't write an article, Victor Wu of Imperial College ported a version of Hope from an Apricot machine to the IBM PC. Victor's version of Hope together with Roger's fine tutorial mean that you can download Hope from BYTEnet Listings and try a declarative language for yourself. BYTEnet Listings also offers a public-domain version of Prolog.

Sacrifices Made

To get in the long articles on the Amiga, the DSI-32, and the declarative languages, we had to cut from this issue some articles and advisories that we badly wanted to run. We had less editorial space at our disposal than at any time since April 1981. The sacrifices included Books Received, Event Queue, Clubs and Newsletters, Chaos Manor Mail, all reviews except those of the Tandy 1000 and IBM Pascal 2.00, several strong feature articles, and additional strong articles on declarative languages. Our apologies to all editors and authors concerned. We will publish as many of the postponed articles as we can as soon as we can. We are considering electronic publication of some of the postponed material.

—*Phil Lemmons, Editor in Chief*



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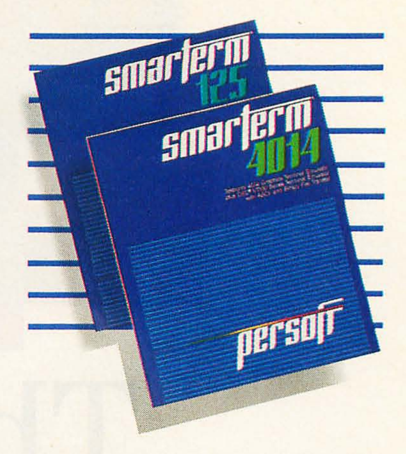
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Sinclair Rescued from Bankruptcy; Sir Clive Loses Clout

In a marathon weekend session, Sinclair Research and Hollis Brothers & ESA Plc, a major distributor of office and educational equipment in the U.K., reached a buy-out agreement that saved the British computer maker from defaulting on more than £14 million of back bills. In the buy-out, Sir Clive Sinclair surrendered his controlling interest in the company and parted with his chairmanship. He will now serve as Sinclair Research's Lifetime President and as a research consultant.

Trouble had been brewing at Sinclair for some time: Christmas sales were disappointing, the QL computer failed to capture a market, the post-Christmas lull was deafeningly silent (industry wags claim that not a single Sinclair was sold during the first 60 days of 1985), and corporate cash was tied up in unsold inventory and research.

The squeeze came when Thorn/EMI, producer of Sinclair's products, demanded that Sinclair clear its tab. Sinclair, unable to meet its obligations, then began moving toward liquidation. But in stepped Hollis Brothers, amid rumors that 10 Downing Street would be pleased to see Sinclair rescued.

Hollis Brothers arranged to pick up £12 million worth of Sinclair stock. To finance the remaining debt, Sinclair will offer current shareholders a 3-for-1 deal. Depending upon how investors exercise their entitlements, Sir Clive Sinclair will end up holding from 8 to 23 percent. He once owned more than 80 percent.

More than 70 percent of Hollis Brothers & ESA Plc is held by Robert Maxwell, who is viewed in England with the same mixture of awe and annoyance as T. Boone Pickens in the United States. Maxwell will serve as Sinclair's board chairman, a position he already holds at London's *Daily Mirror* and the Pergom Press.

Developments Bring Optical Discs Closer to Market

Several developments in June suggested that low-cost optical discs and drives might arrive on the market fairly soon.

Atari showed a compact-disc ROM (read-only memory) player at its booth at the Consumer Electronics Show in Chicago. The company also demonstrated software, developed by Activenture, that accesses the information in an encyclopedia stored in one-third of a 550-megabyte disc. Atari said it will sell CD ROM drives for less than $600 by the end of this year. CD ROM drives use the same 12-cm (4.7-inch) read-only compact discs used in stereo CD players but require additional error-checking and -correcting circuitry. Activenture said the enyclopedia disc might sell for about $200. Neither Activenture nor Grolier would confirm reports that Grolier's encyclopedia is on the optical disc.

Just as 12-cm CD ROM drives seemed likely to hit the market, however, CD developer Sony announced it would be focusing its data-storage efforts on a 13-cm (5¼-inch) disc size to increase disc capacity and perhaps provide an upgrade path to write-once and erasable magneto-optic discs. The Sony "DataROM" 13-cm format was reportedly supported by several other Japanese companies at a standards meeting.

National Memory Systems, Livermore, CA, announced two optical-disc products that include interfaces and software for the IBM PC. The $19,900 NMS-007 uses Optimem's 1-gigabyte 12-inch optical drive and cartridges; NMS says that drive is available now. NMS also plans to offer the $5000 01-OL drive; it uses Optotech's 400-megabyte 5¼-inch drive and cartridges.

New Products Use 65816 Processor

A 4-megahertz version of the 65816 microprocessor, designed to provide more processor horsepower while maintaining compatibility with the 8-bit 6502, is now available to end users. Micro Magic, Millersville, MD, has unveiled MAX-816, an Apple II expansion card that adds a 4-MHz 65816 and 256K bytes of RAM. Micro Magic is developing an operating

(continued)

system, MAX-OS, loosely based on UNIX, to take full advantage of the 65816. The firm also plans to add a 1024 by 1024 graphics card and a cache disk controller to accompany the MAX-816 board. While the basic MAX-816 card will be priced at less than $500 with 256K bytes, up to 1 megabyte can be added to the card, and the 65816 can directly address up to 16 megabytes of RAM.

An earlier 65816 card ($395, 1 MHz) is available from Com Log, Scottsdale, AZ. Manx Software Systems, Freehold, NJ, said it expects to finish a 65816 version of its Aztec C compiler late this year; the compiler will run on the Apple II under ProDOS and DOS 3.3.

C Compilers Expand to New Systems

Manx Software Systems reportedly expected to add native versions of its C compiler for the Commodore 64 and 128 and Apple's Macintosh, as well as an Apple II ProDOS version. The product line, including the $49.95 Apprentice C, was previously sold for the IBM PC and Apple II, with a cross-compiler offered for the Commodore 64. Manx will also provide native compilers for the Commodore Amiga and Atari ST later this year.

Lattice also expected to provide versions of its C compiler for 68000-based systems, including the Commodore Amiga, Atari ST, Sinclair QL, and Apple Macintosh. Both Lattice and Manx are porting cross-compilers to IBM's PC AT.

Two MS-DOS Portable Computers Enhanced

Hewlett-Packard unwrapped the Portable Plus, a 25-line, unbundled version of its Portable. While the Portable included a 300-bps modem, 256K bytes of RAM, and applications software in ROM, the standard Portable Plus provides only 128K bytes of RAM, plus MS-DOS 2.11 and utility software in ROM. A 300/1200-bps modem, ROM applications software, and expansion memory up to 896K bytes will be optional.

Meanwhile, Australian computer maker Time Office Corp. will enter the U.S. market with the Kookaburra laptop computer. Previously available as the Dulmont Magnum, the Kookaburra includes a 25-line LCD, 256K bytes of RAM, an 80186 processor, a video-output port, MS-DOS 2.11, and several applications programs for less than $2000. Time Office also plans to introduce a line of Z80-/80186-based office workstations in the fall.

NANOBYTES

Actrix Computer Corp., Milpitas, CA, which emerged from Chapter 11 bankruptcy protection in May, planned to announce new versions of its Actrix computer that are compatible with IBM's PC, XT, and AT models. . . . **Altos Computer Systems**, San Jose, CA, has developed two multiuser systems. The 2086 is a $19,900 20-user system based on Intel's 80286 processor using the XENIX operating system; it cannot run PC-DOS programs. The 3068, a 30-user system using Motorola's 68020 32-bit processor, is available only to other manufacturers. . . . At the Consumer Electronics Show, **Melodian** planned to unwrap a music system for the Commodore Amiga computer that it claimed will give the Amiga the capabilities of a $75,000 music synthesizer. . . . **Tomy's** new $500 Omnibot 2000 robot can be interfaced to an Apple II or Commodore and has two moving arms as well as the features of its predecessor, Omnibot. . . . Also at CES, **Commodore** announced a $600 10-megabyte hard-disk drive for its 64. . . . **Fujitsu** announced at NCC an 8086-based multiuser computer that uses both the Pick and the MS-DOS operating systems. . . . **Hannes Keller**, Zurich, Switzerland, has developed WitchPen, a programmable word processor with spelling checker; WitchPad, a drawing program using standard IBM character graphics; WitchCraft, a BASIC database-management program generator; and HK, a text-oriented programming language. The programs, currently available in Switzerland, are slated for U.S. release next month. . . . Printer manufacturer **Axiom Corp.**, San Fernando, CA, said that its newest daisy-wheel printers will use a "wedge-back" daisy-wheel technology. A wedge shape on the back of each letter on the print wheel is struck by an indented hammer, which reportedly improves print accuracy and speed. . . . **STM** introduced an IBM PC AT-compatible computer. Configured like IBM's basic AT but with 640K bytes standard, the STM AT will cost $3495. . . . **Faraday** has reduced its IBM-compatible single-board computer to fit onto a single 5-inch IBM PC-style expansion card. While Faraday sells the cards primarily to OEMs, it will sell single Micro PC cards for $695. . . . **AST**, **Quadram**, **Ashton-Tate**, and **Borland** have announced their support of a superset of the Intel/Lotus expanded memory specification.



If you buy a TI 855 printer now, you won't have to upgrade to one later.

Don't tack just any printer on your new PC for now, thinking that you'll get what you really need later. Start with the best, a TI 855 or TI 865 printer. That way you can put the money you'd have spent on a needless upgrade on some other smart investment.

You see, our OMNI 800™ Model 855 is actually three printers in one. For word processing, it delivers letter-quality printing that rivals the best daisy wheel printers around. For data processing, it prints at 150 characters per second. And for your graphics, it reproduces screen or monitor images in the finest detail.

Of course, these advantages are all true of our TI 865 wide-carriage printer, too.

What's more, since our printers are among the easiest to use, you can utilize all the capabilities built into your PC and software right from the start. Instead of sometime later. You even have a choice of over 30 different plug-in type fonts, any three of which can be printed on the same page without ever stopping the printer! Just touch the control panel and it happens. Simple. So every document looks just the way you want it to. Professional.

As for reliability, TI printers are legendary. Just ask any major airline.

So don't downgrade your PC's performance with a printer you'll outgrow in a month. Get yourself a TI 855 or TI 865 printer now. It's easy. Just call 1-800-527-3500, ext. 801, for the TI Dealer near you.

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Creating useful products and services for you.

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If you believe these simple facts about hard disks, you'd be willing to pay more for ours.... fortunately, you won't have to

Avoiding hard disk failures and loss of data is just one of the reasons to buy our hard disks.

Hard disks can fail—there's really no other nice way to say it. Even IBM has problems delivering ATs with hard disks that work. We're not talking about nice, clean, clear-cut failures where the drive seizes up, coughs, and rolls over and dies. We're talking about the insidious little creeping failures that sneak up over time—like a missing sector here or a lost sub-directory there.

There are precautions you can take to protect against failure and ultimate loss of data. Here is what we contribute toward minimizing the potential loss of your data.

Best Drives Available

First, we buy the best drives available. Sounds trite, doesn't it? I mean, a drive's a drive—right? Hardly. You should see some of the junk we get in our labs. Some have such high failure rates that we even questioned our own $10,000 hard disk tester. But when we tested other manufacturers' drives we were assured that our equipment was fine, which just confirmed that the bad hard disks were not only bad—they were real bad.

But that's just the weeding out process. We then take each drive that we've put through our tester and test it again with the controller you've requested. We call this a "tested pair."

DOS Doesn't Do It

In case you're thinking that all this is an unnecessary duplication of what DOS does for you, let me explain the disk facts of life.

If DOS did what you may think it is supposed to do when you format the disk, DOS would map around these bad areas. Unfortunately, DOS doesn't do this.

DOS 2.0 and 2.1 can't enter the bad tracks. DOS 3.0 can, but only on the IBM AT. Unfortunately, as the press has so well documentated, the AT's hard disk develops bad tracks later on.

We do what DOS can't

We believe the problem is so bad, we use a software program that performs a powerful test of your disk drive on all of the IBM or IBM compatible computers—PCs, XTs, and ATs. Our format takes hours to analyze the disk. But when we finish, you know that the bad tracks are really mapped out so you won't write good data that will disappear into a black hole. We even send you a printed statement of our test results.

Our software allows you to type in the bad track locations from the list supplied by the manufacturers, so you'll never write good data to them—even if DOS didn't identify them as bad. The software even lets you save the location of these bad sections to a file, so that you can reformat your disk without spending hours retesting.

We even include a program that will give you continuous comments on the status of your hard disk. No more waiting for that catastrophic failure.

Average Access Time

As you might suspect, some hard disks are faster than others in their ability to move from one track of data to another. The time it takes the hard disk to move one-half way between the beginning of the disk to the end is called the "average access time."

The first generation of 10 megabyte hard disks had average access times of 80-85 milliseconds (msec). But computer users love speed, and guess what—the average access time for the new 20 megabyte hard disk in the IBM AT is only 40 msec. (We sell an AT equivalent with only 30 msec access time!)

There are some legitimate reasons for the shorter access time. It's particularly helpful when there are multiple users on the same hard disk. It's also important when running a compiler. But remember, before you get too wrapped up in the access speed, there's always that ST 506 interface which won't let data transfer from the hard disk to the computer any faster than 5 megabits/second. We've bypassed that choke hole, too. If you want the functional equivalent of a Ferrari with a turbocharger, order our 10 Mbit per second 108 megabyte hard disk with 18 msec of average access speed.

Compatibility

To be sure that your hard disk is 100 percent compatible with the IBM XT you don't need to buy the same hard disk that's in the XT. You can't even be sure what brand hard disk it is because IBM, like Express Systems, goes into the marketplace and buys hard disks from several vendors. However, they buy their XT hard disk controller from only one vendor—the same one we do.

You can buy the IBM XT controller from IBM for $495 or you can buy from us, the functional equivalent, manufactured by the same company that makes it for IBM for only $195. Is it the exactly identical IBM XT controller? No, it's better. First, it takes less power, and secondly, it can control from 5 to 32 megabytes—the IBM controller can work with only 10 megabytes. It is 100 percent IBM XT compatible, and 100 percent is 100 percent. If you want to save a slot, we carry a version that lets you operate two hard disks and two floppy disk drives.

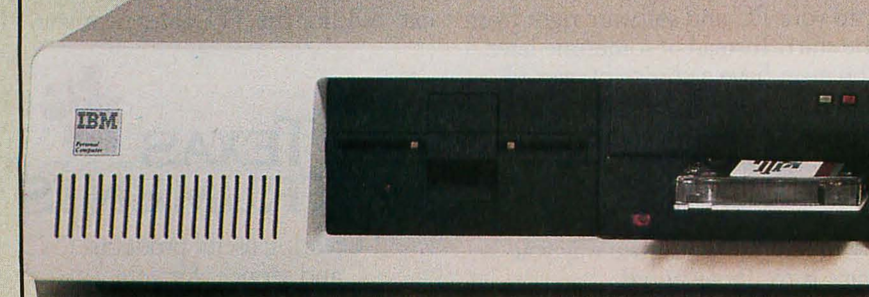
More than 32 Megabytes

You can operate with more than 32 megabytes (the limit of DOS) through the use of "device drivers." Express Systems can supply you with device drivers for our hard disks for over 32 megabytes formatted. But, if you don't have individual files, or databases that are large, you might want to consider one of our controllers that can divide our 65 megabyate (formatted) hard disk into two equal volumes of 32 megabytes each.

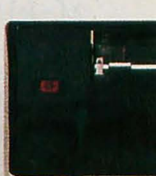
Reliability

We offer you a choice between iron oxide and plated media—the stuff that covers the hard disk and gives it its magnetic properties. Iron oxide is,—well, it's rust. If you inadvertently joust your disk, you may cause the low flying head to dig out some iron oxide. A little rust flake can ruin your whole day. Plated media is more resistant to damage, and if it happens, less data is lost.

We offer both types of hard disks. The iron oxide is older







technology, and quite frankly, manufacturers understand it better. Their better understanding, combined with some of the special head locking mechanisms, gives us peace of mind when we sell you one.

Power

Hard disks consume power. Our small, half-high hard disks consume so little power that you can use them with your existing IBM PC power supply. If you plan to use lots of slots, you'll want to increase your power supply to be safe. We offer the same amount of power for your PC that comes in the XT.

Our Customers

Some folks just never feel comfortable buying mail order. They forget that Sears began as a mail order house or that IBM is now into mail order. But, if it helps, here is a *partial* list of customers who have felt comfortable to buy from us.

IBM	Sears
American Express	Honeywell
U.S. Army	MIT
AT&T (Bell Labs)	RCA
Bausch & Lomb	Lockheed
Xerox	Sperry

Easy to Install

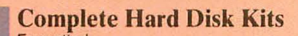
If you're like most of us, raised on the boob tube rather than the Great Books, you'd rather see the movie than read the book. Well, now you can choose to read our installation manual or for only $9.95 more, you can get a VHS or Beta video cassette showing the simple steps for installation.

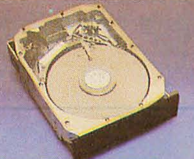


Our VHS or Beta Cassettes make installation easy.

Warranty

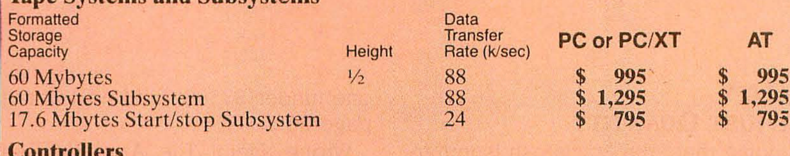
We offer you a one year warranty on our hard disks—the same as IBM on the AT and 90 days on the tape drives. (It's all the manufacturer gives us.) If anything goes wrong with your tape or disk drive or hard disk, send it back in the box it came in. However, we have found that we can usually solve the problem over the phone. So call first for a return authorization number because we can't accept any returns without it.





Complete Hard Disk Kits

Formatted Storage Capacity in Mbytes	Height	Plated Media	Average Access	Transfer Rate	PC or PC/XT	AT
10	½	yes	85 msec	5 Mbits/s	$ 625	$ 430
10	Full	yes	85 msec	5 Mbits/s	$ 625	$ 430
21	½	yes	85 msec	5 Mbits/s	$ 825	$ 630
21	Full	no	30 msec	5 Mbits/s	$ 1,535	$ 1,340
32	½	yes	85 msec	5 Mbits/s	$ 1,095	$ 895
32	Full	no	30 msec	5 Mbits/s	$ 1,775	$ 1,575
65	Full	no	30 msec	5 Mbits/s	$ 2,295	$ 2,070
108	Full	yes	18 msec	10 Mbits/s	$ 4,995	$ 4,995



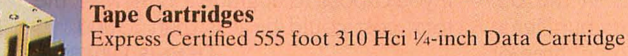


Removable Hard Disk

10	½	no	90 msec	5 Mbits/s	$ 1,095	N/A

Tape Systems and Subsystems

Formatted Storage Capacity	Height	Data Transfer Rate (k/sec)	PC or PC/XT	AT
60 Mybytes	½	88	$ 995	$ 995
60 Mbytes Subsystem		88	$ 1,295	$ 1,295
17.6 Mbytes Start/stop Subsystem		24	$ 795	$ 795



Controllers

All of our hard disk and tape controllers are available separately: Please call for prices.

Subsystem Chassis

Any of our disk or tape units are available in an external subsystem for an additional $250.00. You can mix & match any of our ½ high hard disks or tape drives together or add any single full height hard disk.

Tape Cartridges — $ 35.00

Express Certified 555 foot 310 Hci ¼-inch Data Cartridge

Power Supply — $ 99.50*

130 Watt Power supply

*with the purchase of any drive

Comes complete

All Express Systems products come complete with the appropriate software, tape and/or hard disk controllers, and cables where required. Hard disks are formatted and tested with the PC DOS of your choice. All drive sizes are formatted capacities.

If your application requires a stacking kit, power splitter cables, daisy chain cable, or some other variation, we'll supply these items at a nominal charge. We even ship our hard disks with Command Assist™ an on-line DOS-like manual to give you help with your DOS commands.

More questions?

Because we spend so much attention on the front end with ensuring that our disks will arrive in working order, we have a customer service department that, unlike many of our competitors, has little to do. When you need us, you won't get a constant busy signal.

Call our friendly, knowledgable customer service staff to get answers to your questions—before or after the sale. Our people, who know the PC, can talk you through the sticky parts, and they'll respond to you quickly. Just call us.

How to order

Pick up the telephone and call 1-800-341-7549, to order. We accept Master Card, VISA, American Express and Diners Club. Or send a cashier's check or





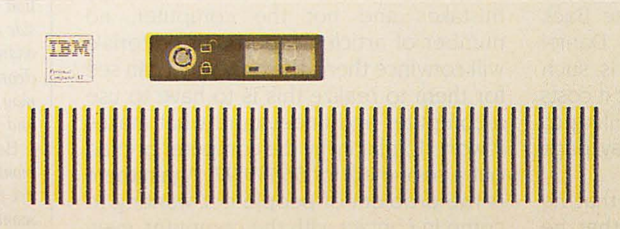


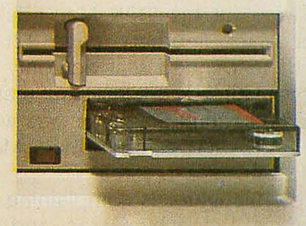


money order (We'll take a check, but you'll have to wait for it to clear) and tell us if you want one of our recommended configurations or you want to mix and match yourself. Corporations with a DUNS number may send purchase orders for quantities over five.



Call Toll Free 1-800-341-7549 Ext. 500
In Illinois call (312) 882-7733 Ext. 500
Express Systems, Inc., 1254 Remington, Schaumburg, IL 60195





Inquiry 116

QUALITY, NOT JUST QUANTITY

In arguing that "the Macintosh is in harmony with the broad lines of evolution in human communication" toward the visual, Jim Hoekema's letter on page 22 of the May BYTE ("The Macintosh Debate Goes On") offers as evidence that, as of 1981, there were 1,055,000 artists in the US, whereas a seventeenth-century burgher in Amsterdam probably saw some three or four hundred pictures in a lifetime.

The particular example he chose is interesting. The pictures seen by our visually impoverished Amsterdamer probably included a few by fellow citizen Rembrandt van Rijn (1606-1669). Poor old Rembrandt, forced to muddle along with the primitive technology of the paint brush. But will even a single painting of his, taken all by itself, ever fail to stand up against all the visual images ever produced with "creativity" enhancers like the mouse, MacPaint, or whatever? The answer need not be based on abstract aesthetic principles. Putting it more mundanely, how likely is it that any art produced on a computer in 1985 will have the staying power to grace a cigar box three and a half centuries from now?

In deciding how visually oriented we are, *how* we see should be as important as how *much* we see. When it comes to shaping the way we look at the world, no graphics program—not even if it bears a name like Rembrandt—will make as lasting a contribution as a graphic artist of the same name.

WILLIAM LOCKERETZ
Brookline, MA

MAC MEMORY

Don Slaughter should spend less time writing to BYTE and more time reading it! First he griped about a lack of RAM-disk software for his 512K Mac ("Take Back Your Mac," February, page 22). Daniel Smith responded that not only is such software already available, but that it costs much less than Slaughter was willing to pay ("A RAM Disk for the Mac," May, page 24)!

Now Slaughter is complaining that he needs a 1-megabyte Mac, and that he won't be able to get a reasonably priced one (under $3500) until next year (May, page 26).

Wrong again! The April BYTE has a "What's New" item on the MegaMac on page 441. The company is MicroGraphic Images. Its telephone number is (818) 368-3482. It offers a complete Macintosh with 1 megabyte of memory for $3495. If you choose to upgrade a 128K Mac, the total cost could be less than $3000.

DENNIS GRIESSER
Long Beach, CA

DON'T BLAME THE COMPUTER

Phil Lemmons's January editorial ("Autonomous Weapons and Human Responsibility," page 6) was very amusing. Being a high school student I can easily picture what would happen if some of the students at Jonesville High were scheduled for lunch at 9 in the morning or at 3:10 in the afternoon.

I'm sure the school mentioned in your editorial had things straightened out within a few days, and people were finding out how beneficial the computer would really be to them. As soon as everybody got over the lunch-period screw-up, they would realize how much easier things were going.

People in today's society are scared of what they think they can't control. If they have to come in contact with a computer, perhaps an automatic bank teller, they're scared to death they will "punch the wrong button" and totally wipe out their life savings. People need to be told of the benefits of computers rather than something to the effect that all computers are good for is screwing up your phone bill or sending junk mail. Humans are responsible for these mistakes and bothers. Magazines like BYTE do a fine job of clearing this up, but if people don't want to believe humans are responsible for these mistakes and not the computer, no number of articles, reports, or editorials will convince them; the only way I can see for them to realize this is to have to use a computer and understand what makes it work. Explain why the computer printed out a phone bill for $6539.97. Again there is the problem of people not wanting to come in contact with the computer, even to learn about it. In come the schools. Our school has increased the number of computers by 300 percent in the past year alone, with more on the way. Already students have taken an interest. Granted, not all of them, but enough to justify the purchase of the machines. The ones who scoff at the computers in the classrooms are simply destined to get a phone bill for $6539.97 and hear the person at the phone company tell them "the computer has made a mistake." If children can learn the basics of computer programming and hardware, then maybe when our generation is older we can use the computer even more efficiently than we do now to simplify our lives and produce programs for school offices that tell the computer *not* to schedule lunch at 9:00 a.m.

MICHAEL A. RUSSELL
Jonesville, VA

SANYO SATISFACTION

I read Robert M. Keith's letter ("Sanyo Support," March, page 304) advising against buying a Sanyo just as I was about to order a Sanyo package by telephone from Computer Creations in Dayton, Ohio. The letter made me think twice, but I went ahead anyway. To my consternation the computer unit, which came as packaged at the factory, refused to format any disk, and I was stymied. But when I called Mr. Jack Kaiser of Computer Creations and told him of my problem, he had the computer picked up from my house, sent to Ohio, and returned in good time all fixed, all at the company's expense.

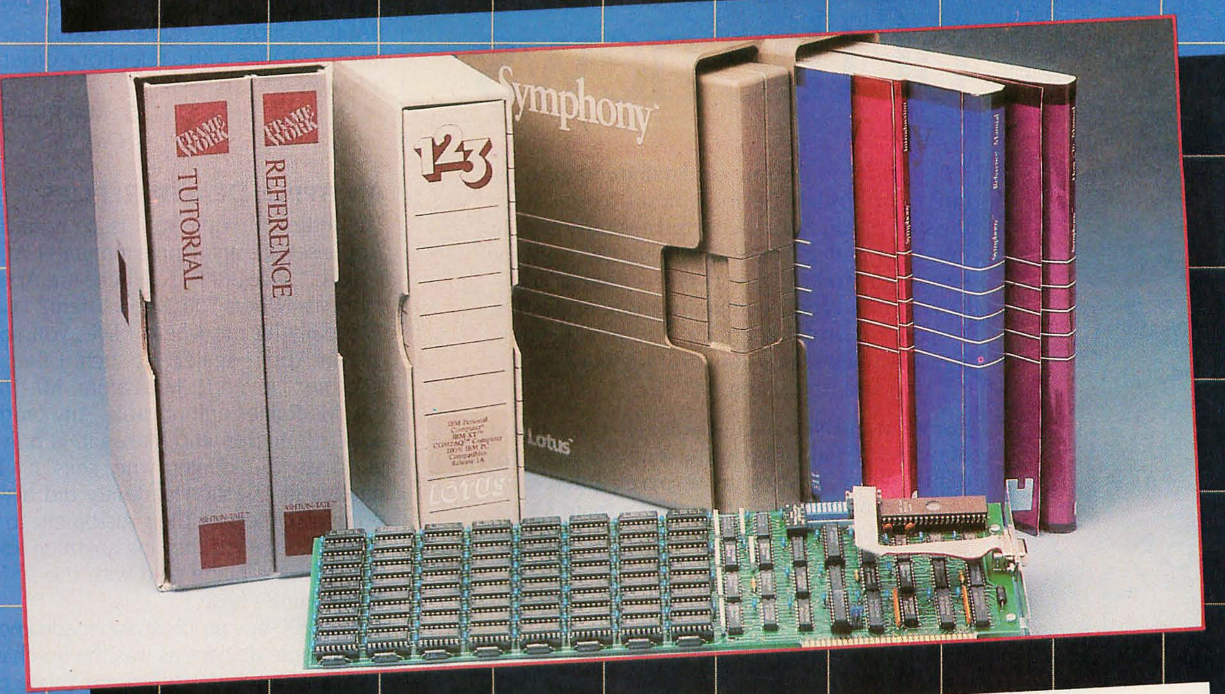
Although I had had no previous hands-on experience with a computer, I was able to write a letter the first day with EasyWriter, and in the first two weeks have

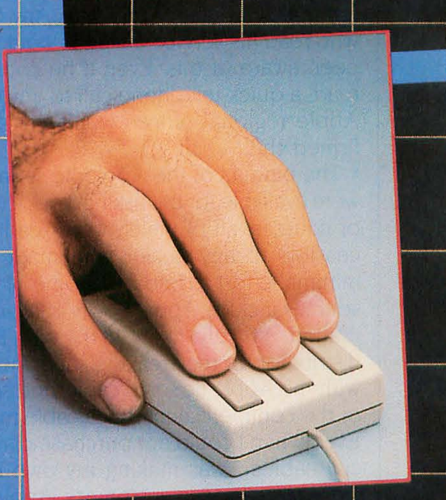
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Because BYTE *receives hundreds of letters each month, not all of them can be published. Letters will not be returned to authors. Generally, it takes four months from the time* BYTE *receives a letter until it is published.*

THE ACCENT™ IS ON EXPANDED MEMORY...
WITH MAYNARD'S NEW LOTUS-COMPATIBLE CARD!





Now, Maynard gives you 2MB of Lotus-compatible Expanded Memory with Accent.™ Designed expressly for your personal computer, Accent™ adds memory power to Lotus 1-2-3,* Symphony,* and all other Expanded Memory programs so you can create larger spreadsheets than ever! An optional mouse places speed, access, and customized commands at your fingertips, saving time and eliminating inconvenient, multi-key cursor controls. Accent™ is available at the finest computer retail stores everywhere. Contact your local dealer or write to us today for product information.

*Lotus 1-2-3 and Symphony are trademarks of Lotus Development Corporation.





430 E. SEMORAN BLVD., CASSELBERRY, FL 32707 305/331-6402

Inquiry 195

established a spreadsheet and succeeded in drawing a few curves from data. Most of the instructions are clear, especially when read the second time, although I confess I had to spend an hour in the library to come up to the starting level in BASIC. I have no regrets about having taken a chance with a telephone order for a Sanyo.

H. G. MacPherson
Oak Ridge, TN

An Apple Dealer Replies

The letters in your April issue regarding Apple service and Apple manuals ("Apple II Blues," page 23, and "Where Are Apple's Manuals When You Need Them?" page 32) really hit me where I live; you see, I am an Apple dealer. As such, I find the treatment given to Mr. Lamar, Mr. Hine, and Mr. Raines unforgivable. Any product sold, no matter who makes it, is only as good as the dealer who sells it. The dealers in question certainly did a very poor job of serving their customers, to the point of not even knowing anything about the software being sold with the system in Mr. Hine's case.

The 1200-bps problem was made known to all Apple dealers, as was the no-charge board-replacement policy for those customers experiencing difficulty. Any dealer who read his service bulletins would have been aware of this. Even if he could not read, a quick telephone call to any of the Apple regional offices would have confirmed this.

The pinouts of the Apple IIc serial port were available for the asking from a variety of sources, all of which were readily accessible to any dealer who made even minimal effort to find out. Some of these sources include Apple's own *Technical Notes* (issued in July of 1984), the Epson distributor for the area, the sheet included with the Apple IIc serial cable, and several of the commercial interface-cable makers. Even when I could not purchase commercial cables I was making my own in the store to sell to my customers. Apple also issued technical information for the second disk port on the IIc that allowed us to modify our existing Apple IIe drives for use on the Apple IIc before we got steady delivery on regular IIc drives.

Ah yes, manuals. Years ago, Apple did supply most manuals with the systems purchased. Starting with the introduction of the IIe, technical manuals became optional, with only an owner's manual being included with the computer. In general, I agree with this policy because, as the type

(continued)



UNIX
UNIX
DOS
VENIX/86 PROGRAMMER MANUAL
VENIX/86 REFERENCE MANUAL II
The Office UNIX System
Our software ties don't bind your personal computer.
And they're knot just for networking, multi-tasking, sharing and typesetting…
Hook up different types of computers so users can exchange information and transfer files. Share expensive resources like disks and printers. Let several people use a PC at the same time.
Keep your favorite DOS applications. With The CONNECTOR™ you can run DOS and UNIX™ applications at the same time.
For a standalone PC UNIX solution, try VENIX/86™. This lean, clean UNIX engine offers the best cost/performance system available for personal computers. Including IBM's, Compatibles, AT&T 6300's, and DEC PC's.
Bogged down scheduling appointments? The Skeduler™ will find a common available time and notify everyone. It also tracks and reminds you of personal appointments.
In-house typesetting can save you time and money. With LaserLink™ it's a breeze. There's no programming to learn or long, complicated codes to key in.
Choose from a quality selection of Multi-user business applications–like UNIFY™– which give you powerful productivity software even a non-programmer can use. And we provide total support with an 800- user hotline.
All this from a single source—Unisource—your complete Unix software solution company.
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UNIX is a trademark of AT&T Bell Laboratories. LaserLink and The Skeduler are trademarks of Unisource Software Corp. VENIX/86 is a trademark and an implementation of VenturCom, Inc. UNIFY is a trademark of Unify Corporation. The Connector is a trademark of Uniforum Software Systems, Inc.

 Inquiry 76

of purchaser shifted from the "hacker" to the novice, the material was more confusing than informative. It was not unusual to be asked, "Why do I have to pay for these manuals when I don't know what they are and don't need them to run my VisiCalc?" Now that the manuals are optional, the opposite situation arises when the purchaser is competent and needs the material. Any dealer worth his salt will stock such reference material in order to meet the needs of all his customers. It is unfair to condemn Apple for the failure of its dealers to act intelligently. Even though Apple has set rather high standards for its dealer network, there are more than enough retailers who are more concerned with shoveling boxes out the door than adequately serving their customers.

The common thread that ran through all three of these letters is that the dealers failed in the most elementary of tasks, that being to support the products that they sold (or sell). In this day when the pressure is on to move more product and to hell with the support, there are some of us out here who really do try. We are the ones who end up holding the hands of those buyers who have been left high and dry by the fast-buck artists and price-only retailers. If there are any other Apple users who need manuals or technical help, call me. My people are competent and can do more than read the numbers on their commission checks.

VERN L. MASTEL
Bismarck, ND

BYTENET RESPONSE

It is 11:57 p.m.; I've been dialing BYTEnet since 7:00 p.m. and getting busy signals or that obnoxious recording telling me that all the circuits are busy and I should try calling back later.

I think I understand the rationale and impetus behind BYTEnet. Typos are eliminated and money saved. It sounds like a great idea. However, the current implementation leaves much to be desired.

Oh, how aggravating it is to read an interesting article that makes references to a missing listing! It defeats the tutorial value of the article. And I subscribe to BYTE to learn.

I think that I'm being shortchanged and that there must be an alternative! At the very least, restore the listings until the load on BYTEnet is reduced.

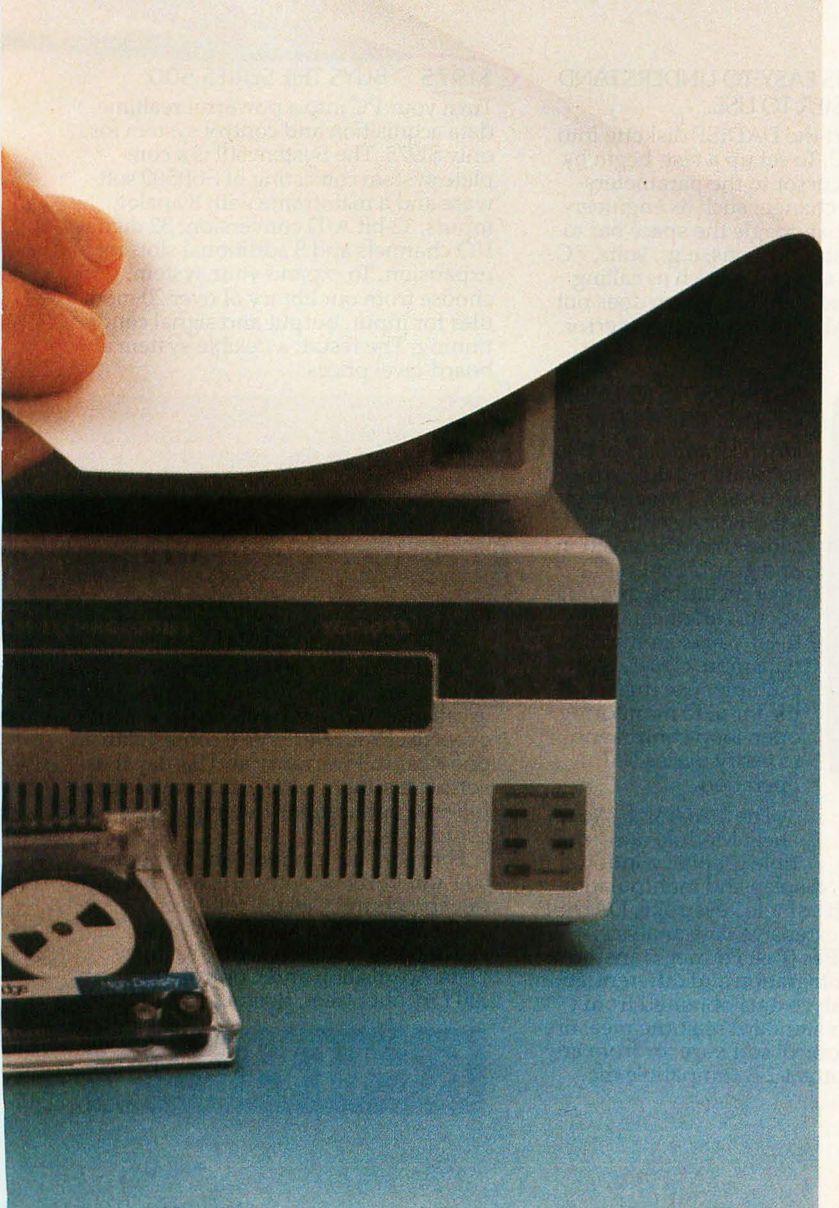
I'm not staying up past midnight, and I'm not thrilled about paying those long-distance rates just to see if a listing is

(continued)



WE INTERRUPT
PRODUCT
BRING
INTRODUCING 5
TALLGRASS TECHNOLOGIES
TG-6135
TALLGRASS TECHNOLOGIES
Scotch DC 600A

THIS MAJOR INTRODUCTION TO YOU SOMETHING REALLY IMPORTANT.



THE BIG NEWS IN DISK/TAPE IS PC/T, A SENSIBLE NEW APPROACH TO ARCHIVAL STORAGE.

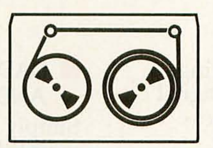
We've tamed tape. And made it docile. By making it DOS-like.

So, while this started as an ad for our five new HardFile™ subsystems, which deliver 25 to 80 megabytes of hard disk storage and 60 megabytes of tape backup, instead we want to introduce you to PC/T.™

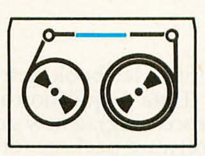
PC/T is a new format that makes tape a more sensible storage solution for personal computers. It puts tape on line, in real time, for instant access. And frees your hard disk for your most current data.

You already know how to use PC/T. Because it responds to standard DOS commands.

Here's the big news: just like any DOS-controlled hard or floppy disk, PC/T enables you to create directories and files on tape. Then you can call up the exact file you need, and change a portion of the tape without having to erase and overwrite the entire cartridge.



Without PC/T, you have to rewrite the entire 60 MB cartridge each time you make a single change.



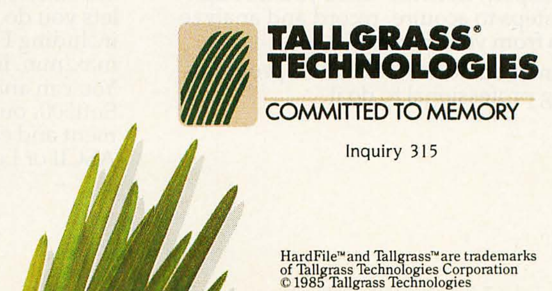
With PC/T, you create and directly access files on tape, just like with floppy or hard disk.

PC/T formats each new tape cartridge, just like you format any hard or floppy disk, locking out bad blocks to assure that every bit of data you write to tape is recorded with utter accuracy.

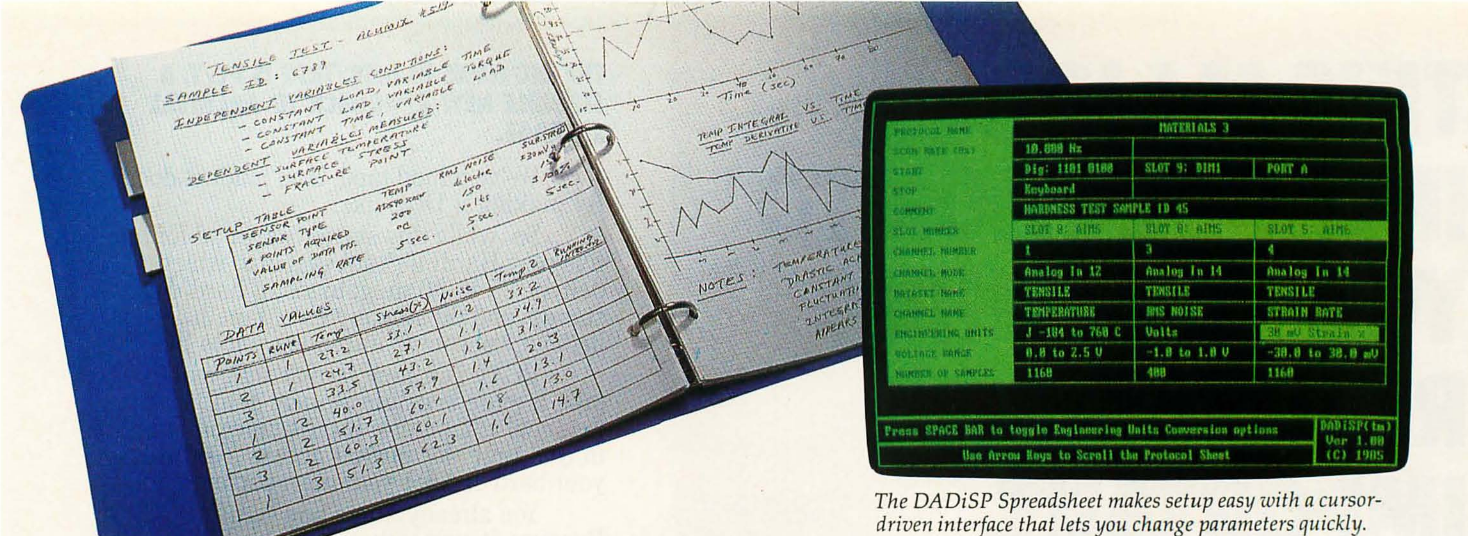
What's more, PC/T gives tape true error correction capability. 50% redundancy during write operations ensures 100% reconstruction of data lost because of operator error, dust and dirt, or everyday wear and tear.

There is a catch. You can get your hands on PC/T just one way: Buy one of our powerful new HardFile subsystems. With disk plus tape. Or tape alone. Which brings us back to where we started. And gives you a place to start. Just call 1-800-228-DISK for the Tallgrass dealer nearest you.

TALLGRASS SELLS MORE HARD DISK STORAGE WITH CARTRIDGE TAPE BACKUP THAN ANYONE IN THE WORLD.



Inquiry 315



The DADiSP Spreadsheet makes setup easy with a cursor-driven interface that lets you change parameters quickly.

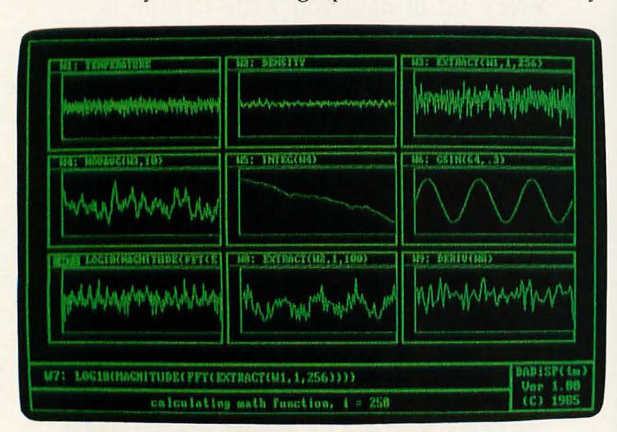
TO MAKE THE KEITHLEY SCIENTIFIC WORKSTATION EVEN EASIER TO USE, WE TOOK A PAGE OUT OF YOUR BOOK.

Your scientific lab book. Introducing DADiSP (Data Acquisition and Digital Signal Processing), a new graphics-driven software package for data acquisition and analysis with Keithley's Series 500 IBM PC-based Scientific Workstation.

DADiSP parallels the way any scientist or researcher normally records and analyzes data in a scientific lab book.

Using a spreadsheet for setup, windows for analysis and zoom graphics for display, DADiSP takes you through the steps to acquire, record and analyze data from your Series 500.

And you don't have to be a programming professional to do it.



DADiSP graphic analysis makes it easy to define each window as raw data or a function of another window. Results are quickly generated for easy interpretation.

DADiSP IS EASY TO UNDERSTAND AND EASIER TO USE.

Simply insert the DADiSP diskette into your IBM PC. To set up a test, begin by moving the cursor to the parameters you want to change, such as engineering units. Next, toggle the space bar to select the test conditions, e.g., volts, °C. If you make a mistake, such as calling for a test condition the system does not support, DADiSP identifies your error. It's that easy.

DADiSP IS FRIENDLY AND FLEXIBLE.

DADiSP consists of two software modules: the DADiSP I Spreadsheet Module is used for test setups, data acquisition and graphic presentation, including dynamic zoom/cursor capability to let you examine the data more closely. For example, use this module for data monitoring, open loop control and to verify Series 500 operation.

The DADiSP II Worksheet Module uses multiple graphic windows, for analysis, display and manipulation of data. With a single keystroke, DADiSP lets you do extensive data analysis, including FFTs (Fast Fourier Transforms), max/min, integration and differentiation. You can analyze data obtained from Soft500, our standard realtime measurement and control software, or from any ASCII or Lotus 1-2-3 compatible file.

$1975 BUYS THE SERIES 500.

Turn your PC into a powerful realtime data acquisition and control system for only $1975. The System 501 is a complete system consisting of Soft500 software and a mainframe with 8 analog inputs, 12-bit A/D conversion, 32 digital I/O channels and 8 additional slots for expansion. To expand your system, choose from our library of over 20 modules for input, output and signal conditioning. The result: a flexible system at board-level prices.



IT'S AN EASY CHOICE BECAUSE IT'S KEITHLEY QUALITY.

Behind the Series 500 is Keithley's 40-year reputation for engineering excellence and low-level measurement expertise. Your Series 500 comes with a one-year full warranty and 90-day free software support. We even provide a toll-free applications hot line. What could be easier?

For more information on the Series 500 and DADiSP software, ask for our new brochure. Call us, toll-free: 1-800-552-1115. (In Massachusetts, call 617-423-7780.) Or write, Keithley Data Acquisition and Control, Inc., 210 Lincoln Street, Boston, MA 02111.



worthwhile. I just dropped you a check for $21, and now you want me to "buy" the listings from Ma Bell?

PATRICK CONROY
Vernon Hills, IL

Phil Lemmons replies:

This letter is representative of several we have received concerning BYTEnet. We're sorry about the trouble you had getting into BYTEnet Listings. We're taking several steps to make program listings more accessible.

1. We're launching the BYTE Information Exchange (BIX), which will handle many simultaneous users.
2. We've increased the free BYTEnet Listings bulletin board to three lines.
3. We're buying a laser printer to permit us to print listings clearly in less space than now required.

We're trying to make arrangements to make listings available in several disk formats but have nothing to announce yet. Any disk copy services who are interested in copying disks for BYTE should contact me.

We're also seeking people who will make BYTE listings available on electronic bulletin boards in foreign countries.

WHAT ABOUT MAGIC/L?

After reading all about various languages in BYTE, I want to bring attention to a language that I have never seen mentioned or advertised. The language, called MAGIC/L, is made by Loki Engineering Inc. of Cambridge, Massachusetts. MAGIC/L is an extensible threaded interactive compiler. It is an exceptionally good development language and includes an assembler that is integrated into the high-level environment and allows access to high-level code and data. This makes a lot of sense. MAGIC/L has a full range of error reporting; when an undeclared routine or variable is encountered during compile, instead of aborting, a word is compiled that generates a run-time error, and the system remains intact. MAGIC/L includes a logging facility that allows all input and/or output to be recorded on a disk file. MAGIC/L also supports modules, precompiled versions of your routines; this eliminates compile time for tested and debugged routines. This only touches on some of the advantages that MAGIC/L gives to programmers. MAGIC/L is available for MS-DOS, CP/M-80, RT-11, and UNIX-68000 in various formats. I have

(continued)

been using a version of MAGIC/L on Digital Techniques' "Touchcom" equipment for a year now and find it indispensable. Perhaps a review of this product is in order.

STAN COPLAN
Philadelphia, PA

Glenn Hartwig replies:

Thank you for your interest. As it happens, we recently received a review of MAGIC/L and hope to be able to run it in the near future.

ASCII TRANSFER

To honor the country where I discovered it, let me present what I will call the Morocco Principle: "To transfer an ASCII file from one computer to another, communications software is needed only in the receiving computer."

Testing was done using an IBM PC with the IBM Asynchronous Communications Package and an HP 150 with DSN/LINK. A Smart Cable joined the Quadboard serial port of the IBM to the standard serial port of the HP. Separately, Dick Roberts established the link between Compaq and Apple computers.

First, use the communications software to put the receiving computer in a waiting state. Then use the operating system of the sending computer to route the desired file through the serial port. For example:

```
A>TYPE MYFILE.TXT>COM1:
```

Of course, the Morocco Principle saves time and money only if unidirectional transfer is sufficient. If not, communications software is needed at both ends.

PAUL-ANDRE DESJARDINS
Rabat, Morocco

8-BIT ASCII DRAFT STANDARD

During 1984, three draft 8-bit character-set standards were developed for the Latin languages of western Europe and the western hemisphere with identical 8-bit code tables. The ANSI draft is called 8-bit ASCII; the ECMA approved standard (ECMA-94) and the ISO draft standard (ISO DIS 8859/1) are called Latin Alphabet Nr 1.

This standard code table is the first 8-bit one intended to facilitate processing by computers (the old 1968 and 1977 ASCII standards are 7-bit standards). Each of the 189 printing characters, including *space*, are one byte. All accented letters are included as single bytes to facilitate processing by software. Eleven U.S. word-processing characters are also included.

Because there is sufficient room in the 8-bit code table for the characters most commonly used in these countries, there are no national or user options in the code table, unlike the old 7-bit ISO 646 standard. Happily for the U.S., the left-hand side is 7-bit ASCII, so the 8-bit standard is upward-compatible with the 7-bit ASCII standard.

Software-application writers and terminal vendors should make plans for support of this standard. They should avoid using the eighth bit in ASCII data for other purposes, such as processing flags, parity, etc. Rather than inventing their own character sets, users should study this new standard to see if it will suffice.

Table 1 is the ANSI/ECMA/ISO 8-bit code table. The ANSI draft is out for public comment until July 14, 1985. Copies of

(continued)

Table 1: *8-bit ASCII Level 1. Note: Columns 0–7, 8–9, and 10–15 are specified in dprANS X3.4–198x, ANSI X3.64–1979, and dpANS X3.134.2–198x, respectively; they are shown for information only. Blank code positions (double asterisks) are reserved for future standardization. Readers are advised against directly implementing this chart.*

				b8	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
				b7	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
				b6	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
				b5	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
b4	b3	b2	b1		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0	0	0	0	00	NUL	DLE	SP	0	@	P	`	p	**	DCS	NBSP	°	À	Đ	à	ð
0	0	0	1	01	SOH	DC1	!	1	A	Q	a	q	**	PU1	¡	±	Á	Ñ	á	ñ
0	0	1	0	02	STX	DC2	"	2	B	R	b	r	**	PU2	¢	²	Â	Ò	â	ò
0	0	1	1	03	ETX	DC3	#	3	C	S	c	s	**	STS	£	³	Ã	Ó	ã	ó
0	1	0	0	04	EOT	DC4	$	4	D	T	d	t	IND	CCH	¤	´	'A'	Ô	ä	ô
0	1	0	1	05	ENQ	NAK	%	5	E	U	e	u	NEL	MW	¥	µ	Å	Õ	å	õ
0	1	1	0	06	ACK	SYN	&	6	F	V	f	v	SSA	SPA	¦	¶	Æ	'O'	œ	ö
0	1	1	1	07	BEL	ETB	'	7	G	W	g	w	ESA	EPA	§	•	Ç	**	ç	**
1	0	0	0	08	BS	CAN	(	8	H	X	h	x	HTS	**	"	,	È	Ø	è	ø
1	0	0	1	09	HT	EM	)	9	I	Y	i	y	HTJ	**	©	¹	É	Ù	é	ù
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z	VTS	**	ª	º	Ê	Ú	ê	ú
1	0	1	1	11	VT	ESC	+	;	K	[	k	{	PLD	CSI	«	»	Ë	Û	ë	û
1	1	0	0	12	FF	FS	,	<	L	\	l	|	PLU	ST	¬	1/4	Ì	Ü	ì	ü
1	1	0	1	13	CR	GS	–	=	M	]	m	}	RI	OSC	SHY	1/2	Í	Ý	í	y
1	1	1	0	14	LS1	RS	.	>	N	^	n	~	SS2	PM	®	3/4	Î	Þ	î	Þ
1	1	1	1	15	LS0	US	/	?	O	_	o	DEL	SS3	APC	¯	¿	Ï	β	ï	Ÿ

C0 (columns 00–01) · GL (G0) (columns 02–07) · C1 (columns 08–09) · GR (G1) (columns 10–15)

BSR X3.134.1 (8-bit ASCII Structure and Rules) and BSR X3.134.2 (8-bit ASCII Supplemental Multilingual Graphic Character Set) are available for $15 each, along with a self-addressed mailing label, from X3 Secretariat/CBEMA, 311 First St. NW, Washington, DC 20001.

THOMAS N. HASTINGS
Maynard, MA

DON'T SELL SOFTWARE, SELL AD SPACE

I was recently talking to a few friends about software piracy. As a result of this discussion, I began to see a possible method to realize profits from this particular situation. First off, computer piracy occurs because software is copyable and almost any protection scheme is breakable. The second reason is that many people are not willing to buy a piece of software but, through various rationalizations, justify themselves in obtaining copies of it. Finally, some software is actually overpriced and of low quality, so the customer

(continued)

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Ven-Tel gives you lots of reasons to buy our Half Card™ modem for your IBM PC or compatible. The Half Card™ is a complete system that lets you communicate with other PCs, mainframes, and databases effortlessly. It includes Crosstalk-XVI® software. It's reliable. It's got all of the features you want. And it's a good value.

Do You Own One of These Computers?

Chances are you do. And if you're thinking of buying a modem, consider the Half Card™. Because of its small size, the Half Card™ fits in more computers, including all of the models we've listed here. The Half Card™ is small, so it fits in short slots or long. That means you can save your long slots for other expansion uses.

IBM: PC, PC/XT, PC/AT, Portable PC, PC 3270
AT&T: 6300
COMPAQ: Portable, Plus, Deskpro
ITT: Xtra
TANDY: 1000
Panasonic: Sr. Partner

CROSSTALK XVI

Effortless Communication

Each Half Card™ comes with Crosstalk-XVI® communications software, by Microstuf. It's the easiest to use, whether you're a beginner or an old hand, and the most powerful. A full on-line help menu makes using Crosstalk® for the first time a snap. It can turn your PC into a terminal on a mainframe computer with its powerful terminal emulation feature. It will even operate your PC when you're not there. You can call into an information service such as The Source or Dow Jones News Retrieval, or transfer files and electronic mail, all at the touch of a button. The Half Card™ connects your computer to the world. Effortlessly.

More Modem for Your Money

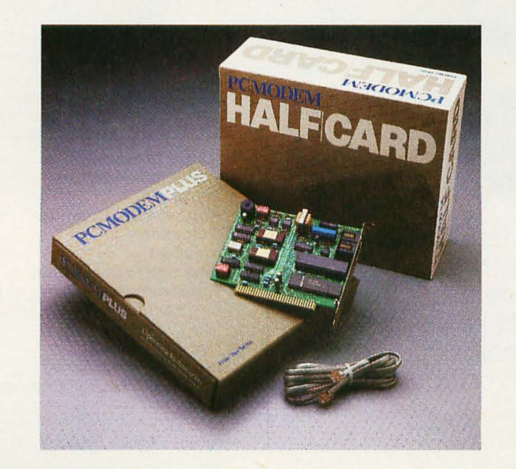
When you buy the Half Card,™ you don't need anything else. The Half Card™ is a complete communications package that includes a full-featured modem and the best known software on the market. Complete easy-to-understand instructions with full technical support on installation and use. And a very competitive price. The Half Card,™ with Crosstalk-XVI® software, retails for only $549.

Reliability

Ven-Tel has been making modems for 10 years. Our experience shows. Ven-Tel's Half Card™ only has about 70 parts, compared to almost 300 on other modems. We reduced the parts by building the first LSI modem chip using advanced switched capacitor technology. What that means to you is greater reliability and lower power consumption, so you can load up your PC with expansion boards and not worry about heat or power problems. And we back the Half Card™ with a full two-year warranty on parts and labor.

Features

- 1200/300 baud auto-dial, auto-answer.
- Uses the industry standard "AT" command set.
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- On-board speaker and extra phone jack for easy switching from voice to data mode.
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- True ring or busy signal detection.



You Can Buy the Half Card™ Anywhere

You can get the Half Card™ at ComputerLand, Businessland, the Genra Group, Entré Computer Centers, Macy's Computer Stores and other fine dealers nationwide. Also from Ven-Tel: the 1200 Plus,™ an external modem and the PC Modem 1200,™ an IBM internal with V.22 international capability.

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THE ADVENTURE CONTINUES . . .



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THE TOOLS YOU NEED.

We've included a powerful set of tools that will save you time and help you organize information, schedule, calculate and a whole lot more. All within a quick keystroke . . . regardless of the software you're running!

You may find a few of these in some "desktop" products . . . but nothing else approaches the power of Homebase!

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- **Template Maker** (for designing your own databases)
- **DOS Services**
- **Rolodex Card Printer**
- **Mailing Label Printer**
- **Data Transfer** (between databases or your other software)
- **Cut and Paste** (great for putting together an Electronic Mail letter that combines a chunk of spreadsheet, some text from a document, and a few notes)

THE EXCITEMENT IS BACK

With the Electronic Mailbag of Your Dreams

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(While you're running WordStar, Lotus, dBase, a compiler or whatever)

We wanted electronic mail that could take care of itself while we were busy on the computer doing something else.
We always felt that there was something strange about having to play postman every time a piece of electronic mail was due. It was always a case of loading up a communications package and either waiting for the mail or going out to fetch it.
Now, we've got it! And you can have it, too. With HOMEBASE, Electronic mail can arrive while you're working in another piece of software. Up in the corner of your screen, a signal lets you know that there's incoming mail. You can read it as it comes in, if you want. Or you can ignore it, and your mail will automatically file itself . . . to be read at your leisure.
When you're sending Electronic Mail, its just as easy. Once you've written and addressed your letter, the rest is done for you, automatically, while you're back working in another piece of software.

CHECK THE DIFFERENCE IN VALUE!

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Amber Systems makes tools for programmers including VSI—The Window Machine. We make mouse drivers, asynchronous drivers and electronic mail packages for a number of companies. Now, we've decided to use these tools, plus some new ones that aren't yet on the market, to produce new concepts in software. Because we make the tools ourselves, our costs, and consequently yours, are the lowest possible . . . with never a compromise in quality.

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AMBER

AMBER SYSTEMS, INC.
1171 S. Saratoga-Sunnyvale Road
San Jose, CA 95129

may not feel that in buying a piece of software he is getting his money's worth. This is our problem. If we assume that software piracy will always exist, that friends will pass along software to friends, then how can money be made in the software market where piracy steals away profits?

Most software can be either considered entertainment or tools. For the purposes of my proposition, I'm only going to consider entertainment software (games). A certain game has a rather specific audience: The user has a specific machine (possibly specific hardware) and can reasonably be assumed to be of a certain age and socioeconomic class—a very specific market of users. Here is the proposal: Since a piece of software can be assumed to attract these users of a specific group, there is a natural grouping to which advertising could be aimed. I am suggesting that instead of selling the entertainment to the user, sell the exposure of the program to advertisers and distribute the programs freely.

What I am saying is, model the entertainment software distribution after other forms of entertainment, i.e., television. Television does not sell the entertainment to its viewers (except examples like movie channels), it sells a captive audience to the advertisers and thus turns a profit. I believe that the same principle could be applied to game software, though in a more discreet manner. So develop the program, make it basically self-explanatory, and sell advertising within the program. Also, since software is notoriously hard to modify, the ads would easily be carried throughout the entire distribution of the game. Methods of implementing this would be to include things like billboards on some game screens, maybe a full-screen ad that appears when the game is paused, ads at the beginning and end of a game, and other visible but nonintrusive advertising. In this manner, the game would still retain all of its lure and glitter, but other elements conveying the advertising message would be included.

So, I am suggesting that there is a way to make a profit and utilize a problem that is currently plaguing the software industry.

EDWARD DEAN TATE, JR.
Seaford, VA

WHY THE RESTRICTIONS?

I would like to ask the software manufacturers why unprotected software has more severe restrictions put on its use than does copy-protected software. A typical copy-protected software license says something

(continued)

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For the PC-XT, we give you:



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- DoubleBarrel© is an internal combination with 10, 22, or 33MB fixed storage combined with 10MB of tape back-up.
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like "You may physically transfer the program from one computer to another, provided the program is used on only one computer at a time," while the license for an unprotected program says something like "This program may be used by only one user on one machine and may not be transferred."

The difference between these two attitudes can be seen in the following example. Suppose I buy an unprotected copy of ClicheWriter, and I spend about two hours a day writing with it. When I'm finished, the program must go back into the box. If I want to work at home, I have to buy another license. If my secretary wants to use the program, she has to buy a copy. If the guy down the hall wants to use it, ditto. Let's say all these things happen so that together we pay for four ClicheWriter licenses. Meanwhile, my competitor down the street buys a protected copy of WordyPlatitude. He uses it for two hours, lends it to his secretary for a few more hours, then to the guy down the hall, then takes it home to teach his kid. Both programs have been used the same total amount, by several users on several machines (though only one at a time). Yet, to avoid being branded pirates and criminals, the users of the unprotected program have spent four times as much.

The question is, Why do the makers of unprotected software trust users not to copy and distribute the program, yet not trust or allow them to use it by one person on one machine *at a time*? Some programs are used many hours a day, but others are used only for an hour or two once a week. Why can the protected ones be freely passed around while the unprotected ones can't? Why must someone who uses a program for an hour a day pay the same license fee as someone who uses it eight hours a day? Why can't the program be licensed for use eight hours a day, regardless of whether that means eight people at an hour each or one person at eight hours?

Let's say you want to buy a copy of AlphaBetsy, that new program that alphabetizes the Christmas card list you typed at random into your word processor. Now this program takes only five minutes to do its stuff. If it's copy-protected, chances are you will be allowed to lend it to all your friends to alphabetize their Christmas card lists, too, and as a result they may help you pay the $100 it costs. Yet, if the program is unprotected, you will no doubt be threatened with immediate violent death if you lend it to anyone. But then, will you want to pay $100 for five minutes' use every few months?

Perhaps software manufacturers should think about just what it is they are licensing. Does the license permit, say, eight hours' use a day without regard to who does the using on what equipment, or does it permit only the use one person can make of it? And if eight hours' a day usage is permitted, what about four people using it *simultaneously* for two hours? Isn't that the very same net use as one user on one machine for eight hours? Or is the manufacturers' attitude one of "Hey, if you can use it all day, great. If not, that's your tough luck"?

I would appreciate some answers to these questions from some software manufacturers.

ROBERT HARRIS
Corona, CA ■



A review of the IBM Personal Computer Family. Vol. 2 No. 2



WHAT'S THE PROGRAM?

Meaningful dialogue. There are two programs from IBM that can greatly improve the quality of our running dialogue with computers. They are the IBM EZ-VU Runtime Facility and the IBM EZ-VU Development Facility.

Think of the EZ-VU Runtime Facility as a mediator in your IBM PC conversations. It handles the exchange of commands and information between you and your application programs through predefined screens. It can give you a single consistent interface with applications written in a variety of languages.

In short, the EZ-VU Runtime Facility lets you concentrate on the essentials of the job you're doing.

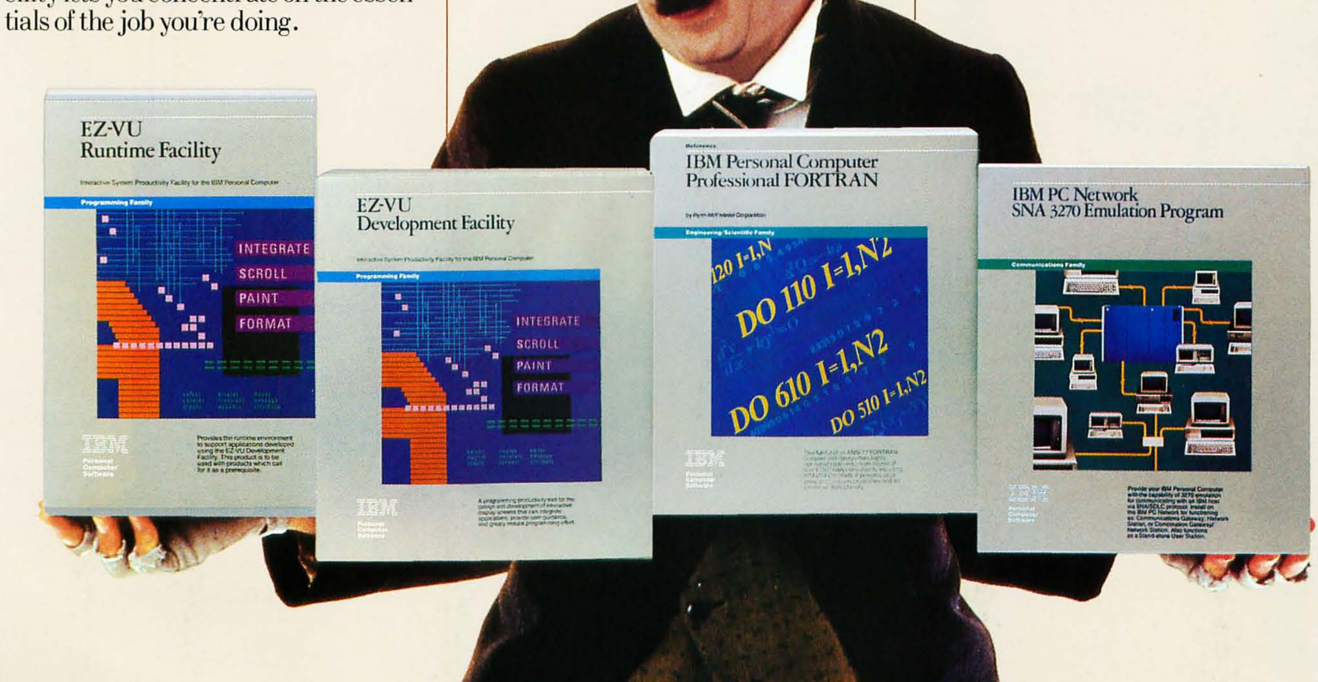
If your job is program development, the IBM EZ-VU Development Facility can help you write menu-driven applications—or revise existing ones—that are both sophisticated and easy to use. It incorporates a screen design tool that works through the function keys on your IBM Personal Computer, so there are no special codes and commands to slow down your design work. EZ-VU also helps make fast work of testing and revising your screen designs.

Two additional points. Both of these EZ-VU programs benefit from years of success by similar dialogue management programs in IBM host MVS,VM, and VSE operating environments. And both run under the IBM TopView program, which allows you to run a number of software applications concurrently.

A quantum leap. Speaking of technological advances, IBM Personal Computer Professional FORTRAN represents a quantum leap forward in FORTRAN for microcomputers.

It's a full ANSI 77 implementation with enhancements that offers an un-

Application management, program development, and communications software from IBM. See next page for IBM PC Network SNA 3270 Emulation Program story.



usual combination of speed and accuracy. Optimization techniques and features such as a full symbolic interactive debug facility are similar to those usually found only in IBM VS FORTRAN and other mainframe FORTRAN compilers.

You can use IBM PC Professional FORTRAN to work on large or small host programs and to recompile existing FORTRAN programs—or sections of those programs—to run on your IBM Personal Computer. It's ability to handle arrays larger than 64KB gives you the equivalent of mainframe capability on a personal computer.

And IBM PC Professional FORTRAN was designed for IBM by Ryan-McFarland Corporation to help you take full advantage of other IBM Personal Computer software, such as the IBM Personal Computer Engineering/Scientific Series graphics development tools.

Make that "quantum leaps."



HARDCOPY

Hidden talent. Think of the many entertaining and useful programming ideas that must exist out there but never find their way to market.

The IBM *Directory* of personally developed software gives you direct access to some of that hidden talent. It's a catalog of unique programs developed by individuals for the IBM Personal Computer Family.

Programs listed in the *Directory* sell for as little as $14.95. They cover a wide range of interests, from entertainment and education to personal productivity and business applications.

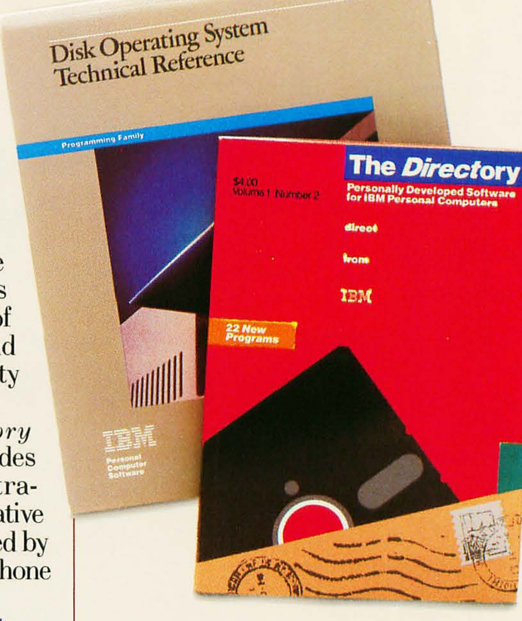
Each program in the *Directory* has a full description that includes system requirements and illustrations or color photos of representative screens. Programs may be ordered by mail or through a toll-free telephone number.

To subscribe to the *Directory*, call 800-IBM-PCSW.

The last word. Or perhaps we should say the last word to date. The new IBM DOS Technical Reference manual contains just about everything you'd want to know about the IBM Disk Operating System Version 3.1 and previous versions 2.1 and 3.0.

That's not to say that new improvements and information won't appear in the future. They will, and you'll be kept abreast of such developments. An update information service is included in the manual's purchase price.

So you'll always have the last word.



Updated versions of the DOS Technical Reference manual and the Directory of Personally Developed Software from IBM.



FAMILY TIES

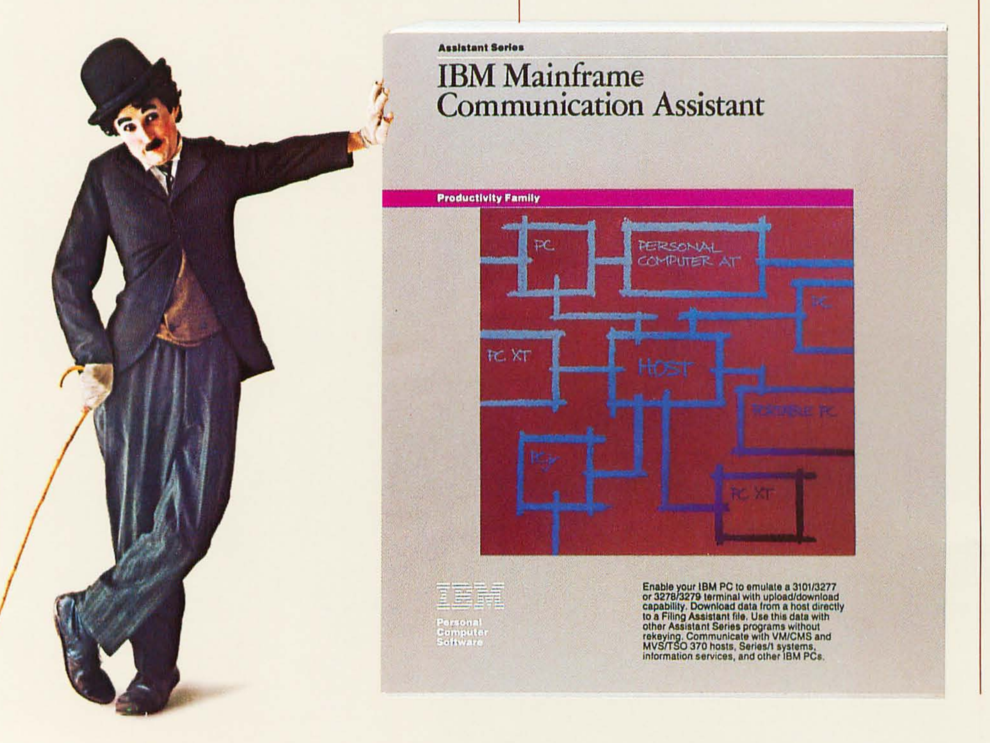
Close connections. The IBM PC Family has always included hardware and software to help you keep in close touch with important contacts.

Last year's announcement of the IBM PC Network, for instance, was an important milestone in communications among the immediate family. It gives you an easy way to share information and hardware resources like printers and disk storage devices.

There are two recent IBM communications software products that extend those IBM PC Family connections even further. They make it possible for you to work directly with data stored on an IBM host computer, to communicate from one network to another, and to do an even wider range of your daily business over the IBM PC Network.

Host communications. The IBM PC Network SNA 3270 Emulation Program, for example, allows your IBM Personal Computer to communicate with an IBM host system through telecommunications lines.

Broaden your IBM PC connections with communications software from IBM.



You then have direct access to the data and programs on the host computer. So if you're working on a branch-office quarterly report, you no longer have to wait while essential data from a headquarter's computer is sent to you and copied for your use. There's also a redirector function that allows you to place the data on a file server for distribution to other stations on your IBM PC Network.

In addition, when the program is installed on an IBM Personal Computer in an IBM PC Network, that PC can act as a communications gateway for other members of the same network. If members of a network need to communicate with more than one IBM host computer—or with different applications on the same host—multiple gateways can be attached to a single IBM PC Network.

And an IBM PC with the IBM PC Network SNA 3270 Emulation Program installed can still be used as a network station doing standard PC work.

You could, for instance, use your IBM PC to create a data set on a host system. You could also create a word processing project on your IBM PC using DisplayWrite 3,* switching easily back and forth between them without terminating either session. The IBM PC Network SNA 3270 Emulation Program also allows you to transfer graphics printing jobs from the host to an IBM PC with a graphics printer attached.

Stand-alone assistance. There's a new addition to the IBM Assistant Series to help handle stand-alone communications between your IBM Personal Computer and a host machine or another IBM Personal Computer. IBM Mainframe Communication Assistant software includes a 3101 and 3270/78/79 terminal emulator for your IBM PC, plus a set of host computer support programs for VM/CMS and MVS/TSO systems.

Mainframe Communication Assistant has the same easy menu structure as other members of the Assistant Series, such as Writing Assistant and Planning Assistant. And it offers a number of unusual features to simplify your communications work.

It can, of course, speedily transfer files between host and PC (or PC and PC). After you've worked with the host file, Mainframe Communication Assistant lets you transfer only the changes you've made—rather than the entire file—back to the host computer.

And, as a member of the Assistant Series, Mainframe Communication Assistant allows you to integrate mainframe database information into Filing Assistant files. You're then able to transfer that information to other members of the Assistant Series, saving the time and effort of reentering data that has been stored on a mainframe computer.

*Follow the proper installation instructions in the IBM PC Network 3270 Emulation Program documentation for DisplayWrite 3.



IBM Quietwriter® Printer offers advanced printer technology and unusually low operating noise level. Shown with sample of letter-quality printing.



HARDWARE NEWS

Quiet, please. There's been a quiet revolution in printer technology. The IBM Quietwriter® Printer is as advanced as the computers it serves. It's versatile, compact, remarkably quiet, and produces work that might make people think you've got a printing press in the back room.

In this case, the spark behind the revolution is a new method of resistive ribbon, non-impact printing developed by IBM. The "Quietwriter" Printer replaces print elements or hammers that strike the page with a unique multi-layer ribbon and print mechanism that virtually "paints" characters on the paper.

As a result, the "Quietwriter" Printer produces superb, letter-quality printing on a variety of papers and in a wide range of type styles. To change type styles you just unplug one font module and plug in another. And because the "Quietwriter" Printer can accommodate two font modules, you can have two type styles online at once.

The "Quietwriter" Printer also allows you to produce a wide array of character graphics either separately or to highlight reports and correspondence.

And it does all of this very, very quietly. At 50 dB, the IBM "Quietwriter" Printer* makes less noise while printing than many printers make while idling. That means you can put the "Quietwriter" Printer wherever it's most convenient; it won't disturb either your telephone conversations or your train of thought.

Unconventional ability. IBM also makes conventional printer technology seem anything but conventional.

Consider the IBM Wheelprinter,* for example. Its printwheel is designed to provide sharp, clear letter-quality printing even after millions of impressions. And the printwheel is easy to change, which is important because there's a selection of over 500 printwheels to choose from. The Wheelprinter's standard features also include both automatic sheet feed and continuous forms feed—optional on many other printers.

The Wheelprinter is reliable enough to take on high-volume office work. It even works with two types of ribbons to suit the requirements of different types of jobs. There's a single-strike ribbon for finished reports or correspondence. For more routine jobs like purchase orders or internal memos, you can use a longer lasting, lower cost multi-strike ribbon.

The Wheelprinter has equally impressive qualifications as a home printer. To begin with, it's remarkably easy to use. The Wheelprinter's integrated paper path provides reliable cut-sheet printing and allows it to do much faster work than you might expect from a 25cps printer. And its acoustically engineered cover makes the Wheelprinter an exceptionally quiet impact printer.

Maybe "conventional" isn't the right word at all.

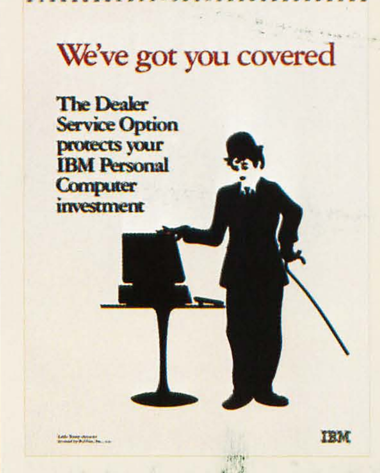
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*These are just two of the various printers available from IBM for the IBM Personal Computer Family.



ON THE STOREFRONT

Extra attention. Even the best equipment sometimes needs a little extra attention. An IBM Dealer Service Option can provide it. It gives you extended service coverage for IBM Personal Computer products, and is available from participating Authorized IBM Personal Computer Dealers either before or after your original warranty expires.



In addition to sparing you the complications of arranging for the job to be done after something has gone wrong, a Dealer Service Option assures you of first-rate work. IBM Personal Computer Dealers have full-time, IBM-trained and authorized technicians on staff as well as direct access to IBM technical experts who can help with unusual or complex questions.

An IBM Dealer Service Option also covers a couple of important additional contingencies. If you move, your service coverage can be honored by a participating Authorized IBM Personal Computer Dealer in your new location. And if you should decide to sell your IBM Personal Computer product, your Dealer Service Option may be transferred to the new owner.





TIPS AND TECHNIQUES

Stop action. If you occasionally sit frozen while screen after screen of information rolls by too fast to read, take heart. There's more than one way to stop that cascade of data and view one screenful at a time.

When listing the directory of a diskette or fixed disk, the command DIR/P will do the trick. After finishing with one screen, press any key to bring up the next.

To slow down the listing of a text file, you could use the CTL/NUM LOCK keys, but that involves keeping both hands on the keyboard and an eye on the screen.

Instead, check your DOS directory listing to make sure the DOS utility program MORE.COM is available. Then, at the DOS prompt A>, type the command line MORE<filename and press enter.

NOTE: be careful to use "<" and not ">"; if you enter the wrong one, you'll destroy your text file.

To view a file called PC-WRITE. DOC, for example, enter MORE<PC WRITE.DOC. That will list a single page of text on your screen and display the message —MORE—. Again, press any key to view next screen.

Voilá, perfect control.

Thanks for this tip to Chuck Harrington of the Athens, Ohio, area IBM PC Users Club.

Thanks also—and apologies for omitting a note of credit in the last issue of *Read Only*—to Ed Smuckler of the Redondo Beach, California, Greater South Bay User Group for his tip about setting screen colors.

For more information about IBM Personal Computer products discussed in this issue of *Read Only*, see your Authorized IBM Personal Computer Dealer or IBM Product Center. To learn where, call **800-447-4700.** In Alaska and Hawaii **800-447-0890.**

FEEDBACK

Leaks Like a Sieve

We've often called benchmarks a "can of worms," and the little critters slithered out of the humus to terrorize us again in the wake of our review of True BASIC ("True BASIC" by G. Michael Vose, May BYTE, page 279). One reader wrote to say the algorithm is wrong (it isn't, as explained below), while a couple of others wrote to ask why we persist in using GOTOs in benchmarks of a language that has constructs that allow you to avoid them. All this reexamination of our infamous Sieve helped us discover some problems, including a false impression created by the review's benchmark table and accompanying graph, that need explanation.

The BASIC Sieve benchmark is a single iteration of the algorithm to find prime numbers between 3 and 14003. The Pascal Sieve benchmark, however, executes 10 iterations of the same algorithm. Our review implies that True BASIC is nearly as fast as Turbo Pascal at executing the Sieve when it is in fact substantially slower. Turbo Pascal's sluggish performance in the Calculations benchmark is an indication that its compiler may optimize the code it generates for the Sieve.

BYTE began using single-iteration versions of the Sieve for system benchmarks (which were all written in BASIC) in conjunction with our review of the IBM PC ("A Closer Look at the IBM Personal Computer" by Gregg Williams, January 1982, page 36.) At the same time, we modified the original Sieve ("A High-Level Language Benchmark" by Jim Gilbreath, September 1981, page 180) from 8190 passes to 7000 to accommodate the small memory available on many of the 8-bit machines to which the PC was compared. We've been consistent with this BASIC benchmarking scheme for system reviews since then.

The queries about unstructured versus structured versions of the Sieve in BASIC raise a valid and interesting point—namely, does structure affect the performance of the algorithm? The answer, in the case of True BASIC, is no—the difference in execution time of the structured version of the benchmark (see listing 1) was a 0.4 second, or 1.8 percent, decrease. We purposely ran the benchmark with GOTOs to maintain consistency among BASIC versions of the test (so that we'd be comparing apples to apples), but the readers who took us to task for not asking if there might be a better way have a legitimate gripe.

Listing 1: *A structured version of the Sieve benchmark, without* GOTOs, *written in True* BASIC.

```
LET startime = time
LET size = 7000
DIM flags(7000)
PRINT "Start One Iteration"
LET count = 0
FOR i = 1 to size
    LET flags(i) = 1
NEXT i
FOR i = 1 to size
    IF flags(i) < > 0 then
        LET prime = i + i + 3
        LET k = i + prime
        DO while k < = size
            LET flags(k) = 0
            LET k = k + prime
        LOOP
        LET count = count + 1
    END IF
NEXT i
PRINT "Done: ";count;" Primes Found"
LET finishtime = time
PRINT finishtime - startime;" seconds"
END
```

Listing 2: *The accuracy benchmarks in two slightly different versions. Using* Y = Y^2 *yields different results than computing* Y = Y*Y. *(In Microsoft* BASIC, X *and* Y *must be declared double precision.)*

```
(a)                         (b)

LET x = 1.0000001           LET x = 1.0000001
LET y = x                   LET y = x
FOR i = 1 to 27             FOR i = 1 to 27
    LET y = y*y                 LET y = y^y
NEXT i                      NEXT i
PRINT y                     PRINT y
PRINT x^(2^27)              PRINT x^(2^27)
END                         END
```

Digressing a moment from the Sieve, another reader suggests we adopt an accuracy benchmark. Adapted from a discussion of numeric precision in the April 1984 issue of *Scientific American* ("Computer Recreations" by Fred Gruenberger, page 19), his suggested benchmark appears in listing 2 and its results in table 1. We like its brevity and simplicity and invite your comments as to its usefulness.

Back to the Sieve, the most recent

(continued)

Table 1: *The results of runs of the accuracy benchmark of listing 2. The correct value (with 10-digit precision) is* 674530.4707.

a = Y=Y^2   b = Y=Y*Y

	y	*x*
Microsoft(a)	8850273	65536
True BASIC(a)	674530.431654	674530.570667
BetterBASIC(a)	674023.631	674530.4704
Microsoft(b)	674530.470612035	65536
True BASIC(b)	674530.431654	674530.570667
BetterBASIC(b)	674492.751149	674530.470738

Listing 3: *The Sieve algorithm with comments.*

```
800 SIZE=7000                  ;set number of odd numbers to examine
820 DIM FLAGS(7001)            ;dimension the primes-flag array
830 PRINT "start one iteration"
840 COUNT=0                    ;set prime number counter to 0
850 FOR I=0 TO SIZE            ;initialize FLAGS array
860 FLAGS(I)=1
870 NEXT I
880 FOR I=0 TO SIZE            ;start loop to strike all odd multiples of primes
                                 from the primes list
890 IF FLAGS(I)=0 THEN 970
900 PRIME=I+I+3                ;compute prime from FLAGS array index value
910 K=I+PRIME                  ;find the index to the first odd multiple of PRIME
920 IF K>SIZE THEN 960         ;test for upper bound
930 FLAGS(K)=0                 ;set flag for non-prime
940 K=K+PRIME                  ;find the index to next odd multiple of PRIME
950 GOTO 920
960 COUNT=COUNT+1              ;increment prime number counter
970 NEXT I
980 PRINT "done";COUNT;" primes found"
990 END
```

reader who claims the Sieve algorithm is incorrect misunderstands how the algorithm uses array indexes. The FLAGS array index is used to calculate the prime numbers in a rather unusual way. Essentially, the algorithm starts by assuming that the first number in the array is prime. Then it eliminates the multiples of the prime, since these numbers are obviously nonprime. The contents of FLAGS (INDEX) = 1 stays unchanged when the number 2 * INDEX + 3 is computed, as this number is always prime; otherwise, it is changed to 0 to indicate that a multiple of PRIME has been calculated. The only numbers tested for primeness are the odd numbers beginning with 3. The prime number 2 is thus not captured in the Sieve and is therefore not reported in a run of the algorithm: The message "1651 primes found" is correct although there are 1652 primes less than 14003 because the Sieve doesn't start looking for primes before the number 3.

Our solution to the problem of the Sieve's obtuseness is listing 3, a more fully documented version of the algorithm.

BYTE's BUGS

A Power Plant Chip?

Dozens of readers have taken us to task for the following sentence on page 458 of the June BYTE: "Each [Sunol Systems'] chip consumes just 100 megawatts when operated from a 5-volt power supply." (See "A GEM Seminar" by John Markoff and Phillip Robinson, page 455.)

Obviously, the sentence should have said "100 milliwatts." We apologize for the error. ■

Introducing In·a·Vision

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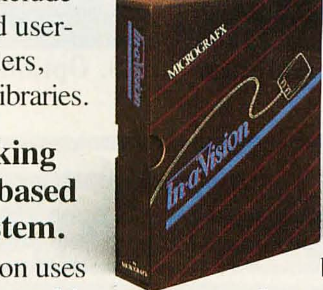
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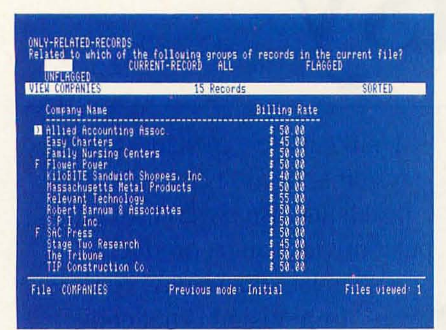
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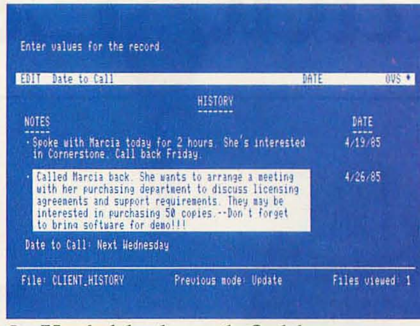
(Most popular graphics cards, plotters and printers supported.) Microsoft Windows compatible. Call for specific operating environment requirements.

Inquiry 206

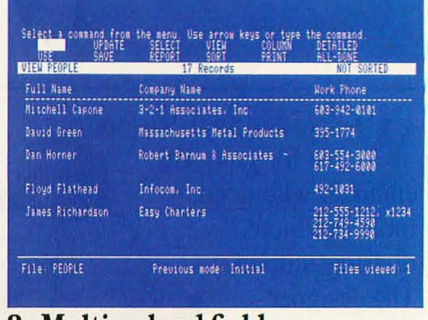
What's a database system doing with a



1. Relational capabilities.



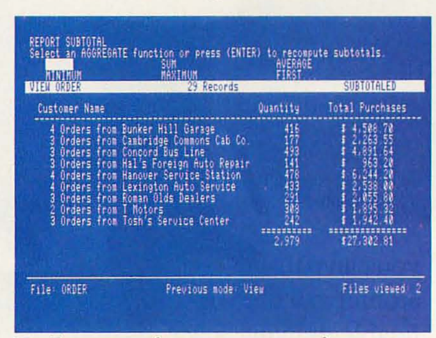
2. Variable-length fields.



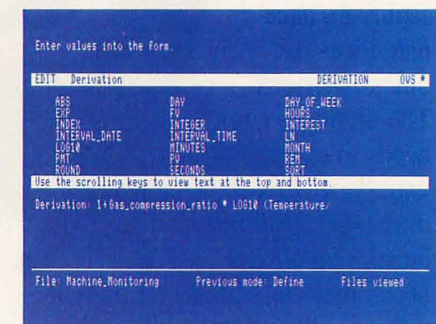
3. Multi-valued fields.



4. Subrecords.



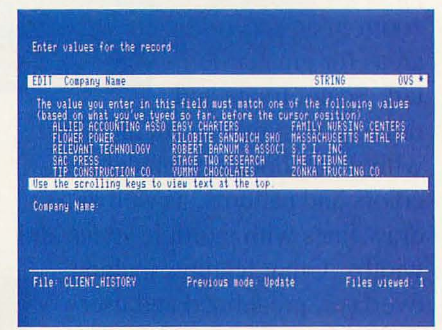
5. Interactive report writer.



6. Calculations.



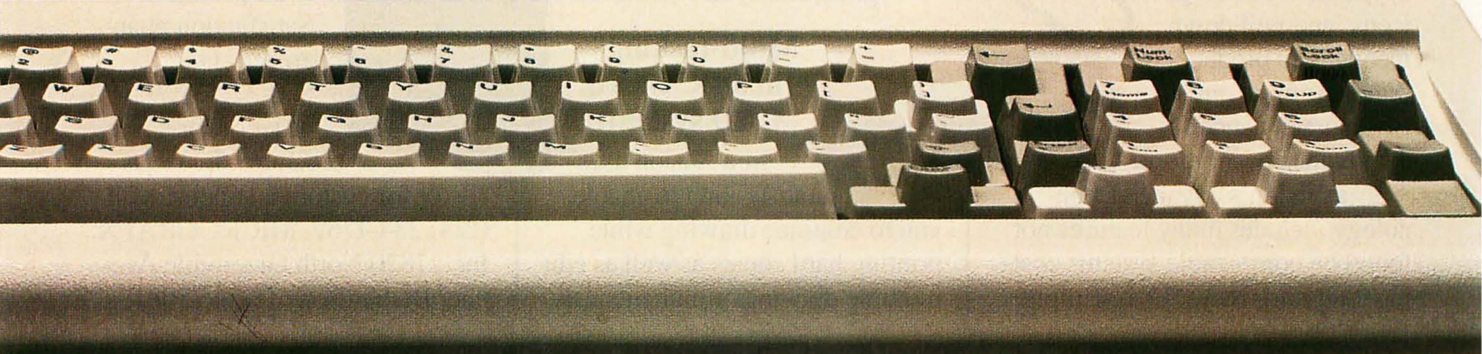
7. Sophisticated data features.



8. Options key.



9. File conversion.



m for non-programmers ll this power?

Cornerstone makes it easy to build sophisticated applications.

Whether you program or not, you expect your personal computer to handle a wide variety of complex jobs. Simply and easily. That's why we designed Cornerstone™ to deliver all the power of a high-end relational (1) database system into the hands of professionals who don't want to spend needless time programming.

The key is flexibility.

To begin with, Cornerstone will grow with you as your needs change. Which means you don't have to plan every last detail of your database in advance. Instead, you can quickly and easily make changes anywhere and at any time—even with data already in the database. You can add a file, field or index, change a report or relationship, or do countless other things.

And Cornerstone's remarkable flexibility also applies to data handling. For instance, variable-length fields (2) let you add notes of any length anywhere in the database—without determining the length of the field in advance. Cornerstone just makes room as you need it. Which means efficient storage, too.

In addition, any Cornerstone field can be multi-valued (3). So you can type in distinct, multiple entries in the same field. Whether five different phone numbers or 200 different notes. You can even have repeating groups of information, like line items in an order form (4).

The flexibility extends to reporting, too. There's no limit to the number or kind of reports you can create with Cornerstone's interactive report writer (5). You can design complex reports with titles, headers, subtotals and totals, and instantly see what your report will look like. Hundreds of reports can be saved for every file and modified at any time.

And Cornerstone has no artificial constraints. You can sort on any field, search on any field.

The calculating power is built in.

Cornerstone has impressive calculating power (6). Mathematical, scientific, statistical, financial, date, time and string functions are built right in. And because it's a full-featured relational database system, new data can be calculated and reported from multiple files. Cornerstone can also perform sophisticated data validation—checking for minimum, maximum, mandatory, unique or restricted values (7).

Easy access for all.

Cornerstone's power is designed to be easily accessible. On-line support, including menus and a Help key, allow even unsophisticated users to handle complex jobs. Experienced users can hide the menus entirely.

What's more, Cornerstone's exclusive Options key (8) always shows you what can be entered next—even if it's a restricted data value from a related field.

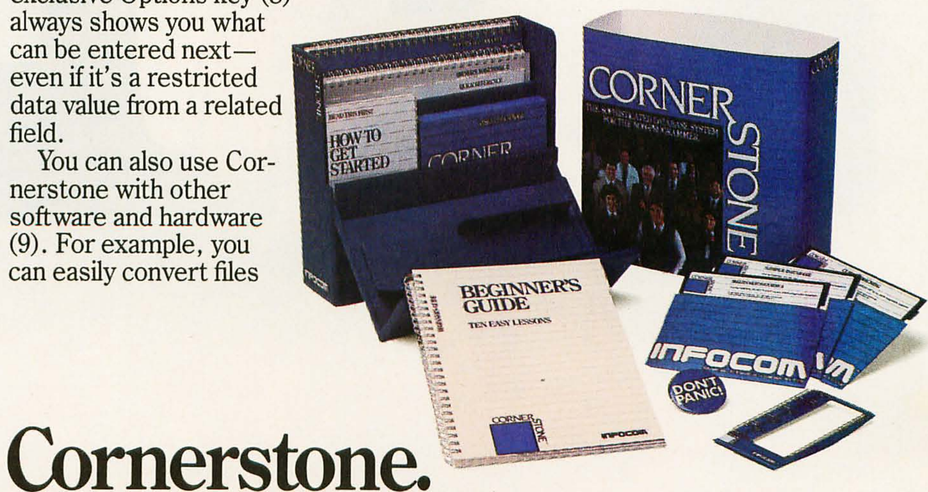
You can also use Cornerstone with other software and hardware (9). For example, you can easily convert files from 1-2-3,® PFS,® dBASE® II and word processors (ASCII) directly into Cornerstone. And you can convert Cornerstone files to a wide variety of file formats, including Mailmerge,™ DIF, 1-2-3, SDF and ASCII. You can even download data from most IBM® mainframe databases, using Micro/Answer™ for Cornerstone.

Cornerstone is a different kind of database system. Created by a company committed to eliminating the barriers between computers and people. It's now available for the IBM PC, PC XT,™ PC AT™ and compatibles, and soon for the Tandy® 1000, 1200 HD and 2000. Suggested retail price $495.

Send for your free demo disk.

To fully appreciate how different Cornerstone really is, you have to try it yourself. For a free demo disk and brochure, call 617-574-0644, or write to Infocom, Inc., Dept. D., 125 CambridgePark Drive, Cambridge, MA 02140. Or see your local Infocom dealer.

INFOCOM™



Cornerstone.

The sophisticated database system for the non-programmer.

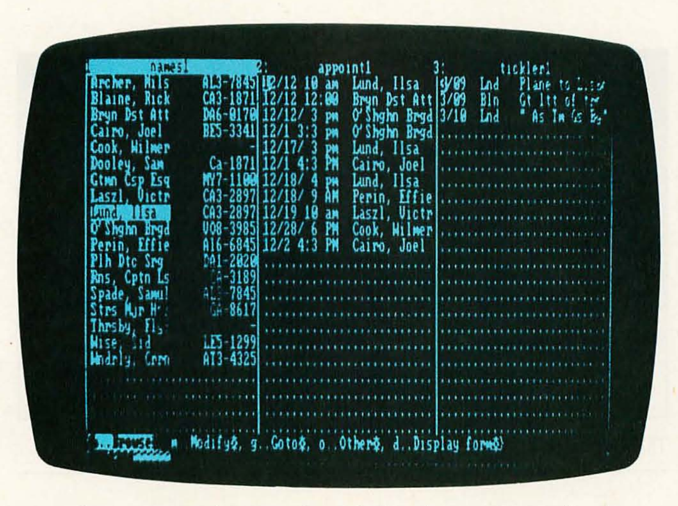
Inquiry 153

Zoomracks

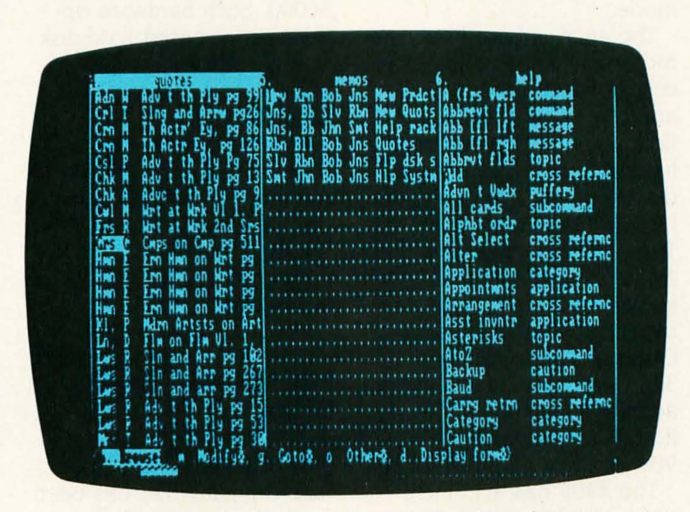
Zoomracks from QuickView Systems is an organizational framework for creating database, text, and appointment applications. It uses a series of files that is similar to a time-card rack. Typical racks can contain cards with appointments, notes, names and addresses, or sales orders. The format of individual cards is user-specifiable; 25 starter formats are supplied.

Both data cards and racks are displayed with Zoomracks' Smart Zooms. This feature differs from windows in that it compresses the information within a card, thereby providing both the essential information and the overall picture associated with the data card. You can tailor Smart Zooms' display to provide an overview of several data racks, a close-up of an isolated data rack, or a view of a single card from a particular data rack.

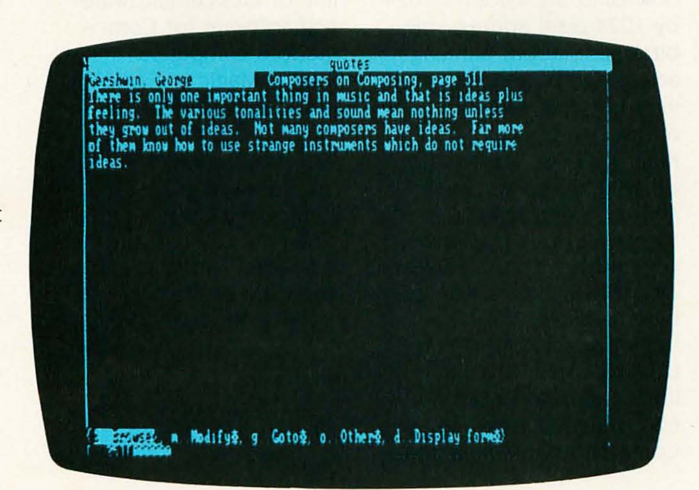
With Zoomracks, you can copy and move fields, cards, and text into different fields, cards, and racks. You can define, alter, and store card-rack templates, and you can browse through or jump among data racks. Other features include macro instructions, utilities to convert dBASE II files, a simple WordStar-like text editor, and data storage in an ASCII-/MS-DOS-file format for conversion to other data formats.



A working overview of Zoomracks with three data racks. Displayed are quotes, memos, and help information in compressed data mode.



A view of a Zoomracks data card, removed from the rack and expanded into full text.



A name, appointment, and tickler file produced with Zoomracks.

Zoomracks can display up to eight racks on screen. It can accommodate 31 fields/cards with 80 characters per line, 250 lines per field, and 20,000 cards per rack. Zoomracks supports display sizes ranging from 25 characters by 6 lines to up to 80 characters by 25 lines. It runs on 256K-byte IBM Personal Computers.

A prerelease, copy-protected version of Zoomracks is $59.95; an unprotected version is $79.95. Purchase of the prerelease package entitles you to a free upgrade to the final version, which is due to ship in November; your name in the users manual if you are the first to suggest an improvement; and a six-month, money-back guarantee. Contact QuickView Systems, Suite 404, 146 Main St., Los Altos, CA 94022, (800) 443-0100, ext. 341.

Modem with Voice Detection

Xecom's MOSART is a 300/1200-bps modem with voice detection. MOSART, which is housed in a 40-pin package, comes with all necessary support circuitry. It requires only the appropriate telephone jack, software, and 2 square inches of the IBM PC's motherboard. Speech-synthesis capabilities are optional.

The basic system, the model XE1201, provides full

(continued)

Bell 103/212A (i.e., 300- and 1200-bps) compatibility. It automatically detects normal speech and drops its carrier signal during voice conversation. MOSART can also decode telephone touch-tone signals.

The model XE1203 extends these features with circuitry to generate speech.

To familiarize designers with the features of MOSART, Xecom offers evaluation kits for use with an IBM PC. Each evaluation kit includes a half-size IBM PC expansion card with telephone and headphone jacks, a headset, and a floppy disk with evaluation software and Xecom's XENIAL communications software.

The XE1251 evaluation kit, with the XE1201 MOSART, is available for $399; the XE1253 kit includes the XE1203 MOSART for $449. In 100-piece quantities, the XE1201 alone will cost $199, while the XE1203 will be $249. Contact Xecom Inc., 374 Turquoise St., Milpitas, CA 95035, (408) 943-0313.
Inquiry 600.

Tektronix AI Systems

The Tektronix Information Display Group has introduced two artificial-intelligence systems that run Smalltalk-80: the models 4405 and 4406. In a related development, Tektronix announced a price reduction for its 4404 artificial-intelligence system. The new price for the 4404 is $11,950, a $3000 cut.

In addition to Smalltalk-80, both the 4405 and 4406 come with a UNIX-like operating system and a C compiler. Each machine is equipped with an RS-232C interface, a Centronics-type parallel printer port, a keyboard, a mouse, and ANSI X3.64 terminal-emulation mode.



The Tektronix 4406.

The 4406 is based on Motorola's 68020 microprocessor, which, in turn, is augmented by a 68881 floating-point coprocessor. Its standard 19-inch, 60-Hz display screen offers a 1280- by 1024-pixel resolution. The 4406 also gives you 2 megabytes of dynamic RAM (expandable to 4 megabytes) with which to work. Other features include a 32-megabyte virtual-memory address space, a 5¼-inch floppy-disk drive, and a 90-megabyte hard-disk drive.

The 4405 has a 13-inch, 60-Hz display screen. The monitor's 640- by 480-pixel display area serves as a window onto the system's 1024- by 1024-pixel addressable bit map. Smooth panning across the bit map is provided by the three-button mouse. Additional equipment includes 1 megabyte of dynamic RAM (expandable to 4 megabytes), 8 megabytes of virtual-memory address space, a floppy-disk drive, and a 45-megabyte hard-disk drive.

Tek Common LISP, Franz LISP, MProlog, a UNIX library, and an EMACS editor are optional. Tek Common LISP is reported to be a full implementation of Guy Steele's Common LISP standard. It is licensed for $6000. Such hardware options as increased hard-disk storage, streaming-tape backup, and Ethernet capabilities are offered.

Prices for the Tek 4406 begin at $23,950. The 4405 starts at $14,950. Write on company letterhead to Tektronix Inc., POB 1700, Beaverton, OR 97075.
Inquiry 601.

MIDI Magic, Music Disks

Q-R-S Music Rolls, a company that has been producing piano rolls for player pianos for more than 80 years, has introduced a line of musical hardware and software for Commodore computers.

MIDI Magic is a one-way MIDI interface that lets you connect Commodore's 64 or 128 computer to MIDI-based musical synthesizers, including the Casio CZ-101. It plugs directly into the Commodore's user port and into the MIDI input socket. A demonstration disk with six songs is supplied.

Q-R-S Music Rolls also offers a collection of music on floppy disks. Many performances feature contemporary musicians and sound quality reminiscent of that achieved by player pianos. The collection includes selections from such artists as Gershwin, Joplin, and Liberace. These compositions can be played back on the synthesizer in any combination of electronic voices. Each floppy disk features six songs.

MIDI Magic costs $49.95. Q-R-S Music Disks are $19.95 each. Contact Q-R-S Music Rolls Inc., 1026 Niagara St., Buffalo, NY 14213, (716) 885-4600.
Inquiry 602.

Color Display Adapter

SubLogic recently introduced a high-resolution color-display adapter card for the IBM Personal Computer. The card has a resolution of 640 by 400 pixels by 16 colors. You can select from a palette of 4096 colors.

An on-board custom microprocessor can draw an average of 70,000 line vectors per second. Software support includes an alphanumeric device driver, a primitives library with source code, high-level language interfaces, diagnostic utilities, and demonstration programs. The board will cost approximately $2500 to $3000.

Contact SubLogic Corp., 713 Edgebrook Dr., POB 4019, Champaign, IL 61820, (217) 359-8482.
Inquiry 603.

(continued)

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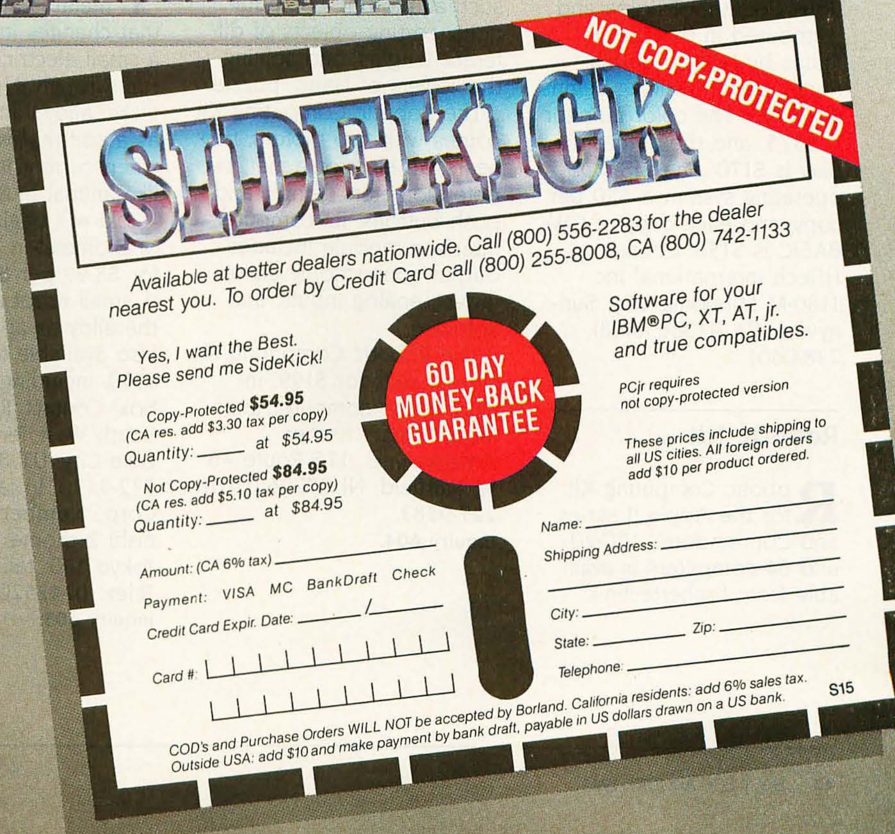
THE CRITICS' CHOICE

"SIDEKICK deserves a place in every PC." **Garry Ray, PC WEEK**

"If you use a PC, get SIDEKICK. You'll soon become dependent on it." **Jerry Pournelle, BYTE**

"SIDEKICK is by far the best we've seen. It is also the least expensive." **Ron Mansfield, ENTREPRENEUR**

"In a simple, beautiful implementation of WordStar's™ block copy commands, SIDEKICK can transport all or any part of the display screen (even an area overlaid by the notepad display) to the notepad." **Charles Petzold, PC MAGAZINE**


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Inquiry 38 for End-Users. Inquiry 39 for DEALERS ONLY.

SAM 3001 AT

The SAM 3001 AT is compatible with IBM's PC AT microcomputer. This machine, built around the 80286 microprocessor, comes with 640K bytes of on-board RAM, a graphics card, a parallel port, two RS-232C serial ports, and a socket for the 80287 mathematics coprocessor. The graphics card is compatible with Hercules-type graphics applications, and user memory is expandable to up to 16 megabytes. A 1.2-megabyte floppy disk and a 20-megabyte hard disk store your data.

PC-DOS 3.0, GW-BASIC, MS-DOS 3.1, and XENIX are supported. Available options include fixed-disk storage of up to 80 megabytes and 14-inch color or amber monitors. Multiuser capabilities and multifunction boards are planned for future release.

The SAM 3001 AT is manufactured by Samsung Semiconductor Telecommunications Co. Ltd. of Korea and distributed in the United States by HiTech International. System pricing begins at $4395. The color monitor is $375, and the amber display is $170. The MS-DOS operating system is $50 per copy, and each copy of GW-BASIC is $150. Contact HiTech International Inc., 1180-M Miraloma Way, Sunnyvale, CA 94086, (408) 738-0601.



The SAM 3001 AT.

Robotic Kit

Robotic Computing Kit for the Apple II series and Commodore's VIC-20 and 64 computers is available from fischertechnik. With this kit, you can build small, stationary robots that perform a variety of tasks, such as plotting computations, sorting objects of different lengths, and solving the Towers of Hanoi puzzle.

The Robotic Computing Kit comes with two motors, two gears, an electromagnet, two potentiometers, lamps, and push buttons. Its computer interface module includes output connections, digital inputs, analog inputs, and software.

The Robotic Computing Kit system sells for $199, including the computer interface. Contact fischer America Inc., 175 Route 46 W, Fairfield, NJ 07006, (201) 227-9283.

Inquiry **604.**

Biometal

Toki Corporation's Biometal is a metallic alloy that changes its shape when a small electrical current is run through it. This titanium-nickel alloy can be shaped as a coil that will contract when current is applied, just like animal muscle tissue.

Toki will begin selling coils of Biometal in September for $8.99 per 8-inch length. A small robot arm that uses the alloy as an actuator is also available for about $150, including controller box. Contact Toki Corp., 850 South West Temple, Salt Lake City, UT 84101, (801) 532-5430. In Japan, Toki Corp., Number 11-11, Ebisu-nishi 2-chome, Shibuya-ku, Tokyo 150; tel: 03-461-1961; Telex: 02425204 TOKION J.

Inquiry **605.**

The System/36 PC

IBM has announced a desktop version of its System/36 minicomputer with a list price of less than $6000.

The System/36 PC, which is about the same size as the IBM PC system unit, requires an IBM PC, PC XT, or PC AT as its console and communications server.

You can connect three workstations to the System/36 PC in addition to the IBM PC. Optionally, you can link a pair of workstations and a system printer to the System/36 PC. The console PC can function as a workstation. Each workstation can execute System/36- and IBM PC-based applications concurrently.

The System/36 PC hardware comprises 256K bytes of memory, a 40-megabyte hard-disk drive, and a 1.2-megabyte 5¼-inch floppy-disk drive. A second 40-megabyte hard disk can be added, and memory can be increased to 512K bytes.

IBM says that the System/36 PC is object-code-compatible with its two 8-inch-disk-based versions of the System/36. IBM plans to transfer software for these machines to the smaller format for the System/36 PC.

The System/36 has a list price of $5995. Its operating system is $995. It will be sold through selected retail stores. The IBM PC requires a special adapter card and software. For the name of your nearest dealer, call (800) 447-4700; in Alaska and Hawaii, call (800) 447-0890.

Inquiry **606.**

(continued)

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Inquiry 40 for End-Users. Inquiry 41 for DEALERS ONLY.

Conquest PC Turbo

The Conquest PC Turbo is a single-board computer that's compatible with the IBM PC.

It comes with a switch-selectable 4.77-/8-MHz system clock, 256K bytes of memory, a keyboard, single serial and parallel ports, and five expansion slots. RAM memory is expandable to 1 megabyte without using an expansion slot. It also has a floppy-disk controller and video-adapter card built in.

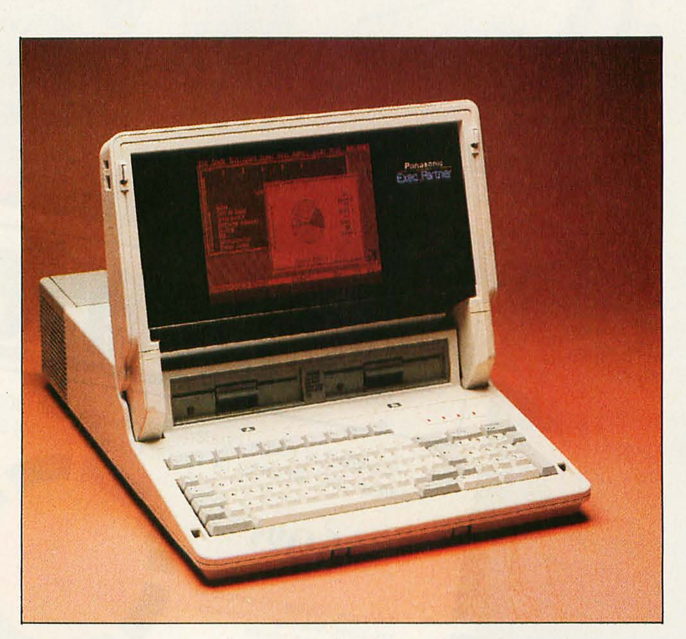
Twin slim-line 360K-byte floppy-disk drives serve as your mass-storage devices. Optionally, the Conquest PC Turbo can be outfitted with half-height 10-, 20-, or 40-megabyte hard-disk subsystems. Half-height streaming-tape backups are also available.

The Conquest PC Turbo supports PC-DOS, MS-DOS, CP/M-86, Concurrent CP/M, and such applications programs as Lotus 1-2-3, VisiCalc, dBASE III, and Multiplan.

With the dual floppy disks and power supply, the Conquest PC Turbo begins at $1695. Contact Microshop Computer Products, Unit K, 2640 Walnut Ave., Tustin, CA 92680, (714) 838-7530.
Inquiry 607.



The Conquest PC Turbo.



The Executive Partner has a 640- by 400-pixel gas-plasma display.

Video Digitizer and BASIC Enhancement for Commodore

Cardco has introduced a pair of products for the Commodore 64: Digi-Cam, a video digitizer, and S'more BASIC, an enhancement to Commodore BASIC.

The Digi-Cam system includes a Panasonic monochrome video camera, a digitizer, software, and necessary cabling. It takes 3 seconds to produce a 320- by 200-pixel screen image in five shades of gray. Images can be stored on disk, transmitted over a modem, and printed. The software lets you manipulate the digitized image.

Digi-Cam is $249.

S'more (Super Memory Optimized RAM/ROM Expansion) BASIC gives you more than 60 new or enhanced BASIC commands and functions, including automatic line numbering, a program renumbering facility, and an undo command. This $69.95 cartridge lets you use more than 60K bytes of RAM for BASIC programming, as opposed to the Commodore's usual 38K-byte limitation. A companion BASIC compiler will be available next month for $39.95.

Contact Cardco Inc., 300 South Topeka, Wichita, KS 67202, (316) 267-3807.
Inquiry 608.

Executive Partner

Panasonic's Executive Partner is an IBM PC-compatible portable computer equipped with a 640- by 400-pixel gas-plasma display. It uses the 8086-2 microprocessor, which features selectable clock speeds, 256K bytes of RAM (expandable to 640K bytes), two 5¼-inch floppy-disk drives, an internal clock/calendar, and a built-in thermal-transfer printer.

The Executive Partner's keyboard is attached. A single 5¼-inch (i.e., IBM PC XT-length) expansion slot and an external bus port are standard. The Executive Partner measures 5 by 16 by 21 inches, weighs 28 pounds, and is AC-powered.

The Executive Partner is $2595, which includes MS-DOS and BASIC. Contact Panasonic Industrial Co., One Panasonic Way, Secaucus, NJ 07094, (201) 348-7183.
Inquiry 609.

(continued on page 380)

PC WEEK'S PRODUCT OF THE YEAR
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TURBO GRAPHIX TOOLBOX™ $54.95



High resolution monochrome graphics for the IBM PC. The Turbo Graphix Toolbox will give even a beginning programmer the expert's edge. It's a complete library of Pascal procedures and functions. Tools that will allow you to draw and hatch pie charts, bar charts, circles, rectangles and a full range of geometric shapes. Procedures that will save and restore graphic images to and from disk. And much, much, more. You may incorporate part or all of these tools in your programs and yet we won't charge you any royalties. Best of all, these functions and procedures come complete with commented source code on disk ready to compile.

TURBO TUTOR™ $34.95

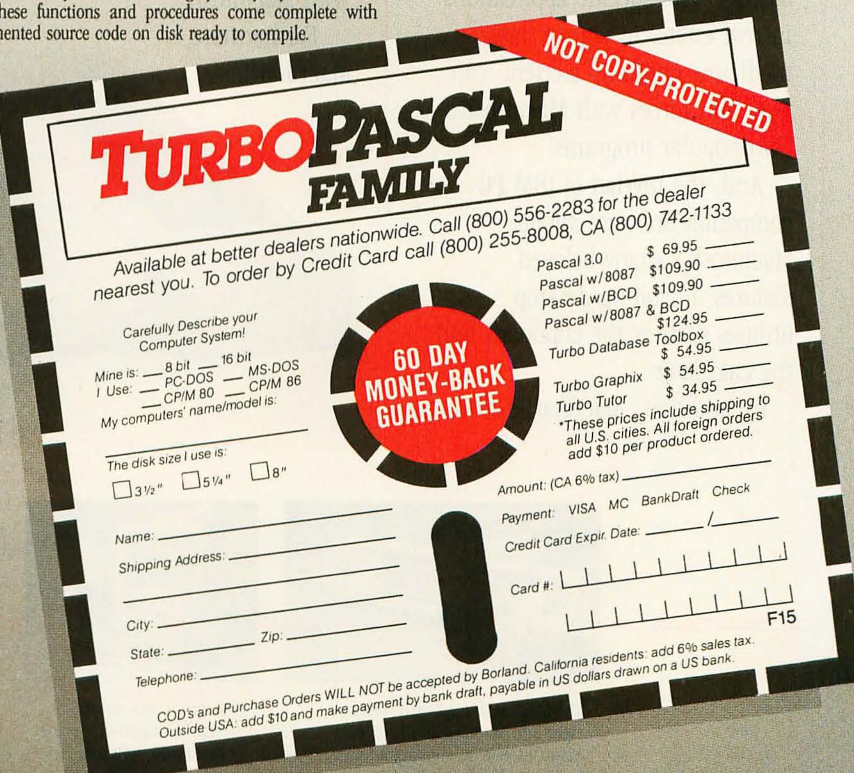


From start to finish in 300 pages. Turbo Tutor is for everyone from novice to expert. Even if you've never programmed before Turbo Tutor will get you started right away. ***A must.*** You'll find the source code for all the examples in the book on the accompanying disk ready to compile. Turbo Tutor might be the only reference on Pascal and programming you'll ever need.

TURBO DATABASE TOOLBOX™ $54.95



The Turbo Database Toolbox is the perfect complement to Turbo Pascal. It contains a complete library of Pascal procedures that allows you to sort and search your data and build powerful applications. It's another Borland set of tools that will give the beginning programmer the expert's edge. ***Get started right away: free database!*** Included on every Toolbox disk is the source code to a working data base which demonstrates how powerful and easy to use our search system, Turbo-Access, really is. Modify it to suit your individual needs or just compile it and run. ***Remember, no royalties!***



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Inquiry 42 for End-Users. Inquiry 43 for DEALERS ONLY.

IBM's best efforts are now going into Macintosh.

Macintosh and IBM PC software. Compatible at last, thanks to MacCharlie, a rather innovative coprocessing system.

And imagine the consequences.

Nearly 10,000 IBM PC software programs designed for general business and specific applications in real estate, insurance, law, medicine, banking, etcetera, can now join forces with Macintosh's own popular programs.

And, the myriad of IBM PC-compatible software adopts Macintosh's many beloved features, including desktop utilities such as the clipboard and the calculator.

In addition, MacCharlie allows IBM PC and Macintosh data files to be exchanged. Talk about flexibility.

But the good news gets better.

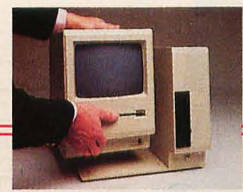
You see, MacCharlie delivers hardware compatibility, as well. For example, IBM letter-quality printers can be easily used with Macintosh.

Furthermore, MacCharlie now allows Macintosh to perform virtually any networking an IBM PC can perform. Even to the extent of tying in with IBM mainframes.

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B·O·O·K R·E·V·I·E·W·S

BEGINNING MICRO-PROLOG
J. R. Ennals
Harper & Row
New York: 1984
196 pages, $15.95

MICRO-PROLOG: PROGRAMMING IN LOGIC
K. L. Clark and F. G. McCabe
Prentice-Hall
Englewood Cliffs, NJ: 1984
416 pages, $18.95

A SOFTWARE LAW PRIMER
Frederic W. Neitzke
Van Nostrand Reinhold
New York: 1984
157 pages, $24.95

EXTRATERRESTRIALS—SCIENCE AND ALIEN INTELLIGENCE
Edward Regis, editor
Cambridge University Press
New York: 1985
286 pages, $39.50



BEGINNING MICRO-PROLOG
Reviewed by Ramachandran Bharath

If you're seeking a lucid introduction to the Prolog language and its growing importance, or if you're interested in the role of computers in education, I recommend you read *Beginning Micro-Prolog* by J. R. Ennals. For people interested in extensive programming, this book could serve as a good lead-in to Clark and McCabe's text *micro-PROLOG* [reviewed next] or Clocksin and Mellish's *Programming in Prolog* (New York: Springer-Verlag, 1982), although the latter uses a different version of the language. Ennals also covers Prolog's background in relation to fifth-generation knowledge information processing systems.

This book is partly a report from a project entitled Logic as a Computer Language for Children, in progress at London's Imperial College of Science and Technology. The rest of the book is a tutorial introduction to the micro-PROLOG version of Prolog used in that project.

Ennals begins with a quick introduction to logic programming and what makes Prolog, the first widely used language based on the concept of logic programming, different from "classical" languages. He explains that in conventional programming languages the focus is on designing a step-by-step procedure that consists of commands that match the step-by-step operation of the hardware operations. This is why these languages are sometimes referred to as procedural or imperative languages. But the concept of programming in logic emphasizes declarations or assertions of the relationships between, and the rules applicable to, the various objects or entities involved in the problem. The task of deriving the necessary results is left to the computer.

Because of this fundamentally different approach to what constitutes a program, Prolog makes a programmer be concerned with specifying logical relationships rather than designing procedures. In other words, a Prolog program is a description or declaration of the problem, and the Prolog interpreter undertakes the task of developing the solution procedure. Ennals provides simple examples to illustrate these ideas. Using these concepts as a starting point, he argues that a language like Prolog is more suitable than procedural languages for human beings since it emphasizes specification as the human's share of

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ILLUSTRATED BY IVAN CHERMAYEFF

BOOK REVIEWS

the labor, with procedural details being the computer's share.

Ennals mentions that the project at Imperial College shares the educational philosophy Seymour Papert discusses in *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980), although the project uses Prolog and not Logo. Indeed, even as I read *Beginning Micro-Prolog* I found it almost as enchanting as Papert's classic because the same concerns come through—for instance, finding ways to use computers as instruments to promote human worth and development rather than making them tools that limit people.

The core of the book is in the third chapter, a description of teaching materials used for educating children between the ages of 8 and 13. Guidance notes for teachers are also included. This part of the book is valuable to anyone interested in learning the general principles of Prolog. Even if you have no access to the micro-PROLOG interpreter that runs on MS-DOS and CP/M systems, reading this chapter and trying the examples (for which solutions are provided at the back of the book) should help you get a working knowledge of how to program in this language. Even though the syntax of micro-PROLOG is slightly different from the version in Clocksin and Mellish's book, which is more or less the standard, the differences are not great. A person who has learned the basics of the language from micro-PROLOG could adjust easily.

Particularly interesting is Ennals's presentation of the principles of list processing. He provides specific examples of how writing programs and querying databases are made easier by having data in the form of lists rather than in individual items. A representative example is a set of geographical data in the form of a list:

((city country) location (latitude longitude))

Ennals shows how list-processing functions for extracting parts of a list or sublists make it convenient to formulate simple Prolog programs for answering questions like Which cities are east of London? Is there any city east of Moscow? and so on.

Next, Ennals covers the wide range of subjects for which Prolog would be appropriate as a teaching medium, such as languages, science, historical simulation, and information retrieval.

In a chapter entitled "Prolog for Greater Things," Ennals discusses a variety of issues. In particular, he emphasizes the suitability of a Prolog-type language for designing expert systems. He quotes the view of the Japanese Fifth Generation Project that "Prolog seems to be the best suited as the starting point for knowledge information processing." You can see the rationale behind this view when you look at what underlies successful expert systems, such as those for medical diagnosis or geological prospecting. Essentially, the expert system mirrors the working of the human expert by embodying "if . . . then" rules that deduce actions to be taken or diagnoses to be made.

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These are usually referred to as "production rules." Since a Prolog program consists of logical specifications or rules, the translation of rules developed for expert systems into the form of a Prolog program is straightforward. While it is true that an expert-system program could be written in a conventional procedural/imperative language, its modification to embody new knowledge and rules would be an involved process. In Prolog or LISP, however, such modifications are natural. Prolog would help free users from worrying about the procedures for solving problems and allow them to concentrate on analyzing and specifying problems.

Ennals's concluding claim is that teaching Prolog would have multiple advantages and a significance much beyond that of teaching computer programming. Ennals's statement that by learning Prolog "children are being prepared for the world of the 1990s" seems to me a persuasive argument.

The subjects dealt with in this book are important and interesting for general readers as well as for those who specifically want to learn more about Prolog. I did not notice any misprints or errors in the body of the book. On checking a fair sample of the solutions to problems, I noticed only one minor error (the solution to problem 12 on page 45), but this would not mislead you.

Ramachandran Bharath is a professor in the Department of Management, Marketing, and Computer Information Systems at Northern Michigan University (Marquette, MI 49855). His book Introduction to Programming in Prolog *is scheduled for publication this year.*

MICRO-PROLOG: PROGRAMMING IN LOGIC
Reviewed by Margaret M. Sklar

Prolog is a relatively new language, both chronologically and conceptually. K. L. Clark and F. G. McCabe, authors of *micro-PROLOG: Programming in Logic*, and B. D. Steele designed micro-PROLOG for microcomputers. The authors' claim that micro-PROLOG contains all of the significant features of mainframe Prolog seems well founded. It's a very sophisticated system, allowing the user to perform functions as simple as presenting queries about an existent (user-created) database and other functions as complex as creating expert systems that can answer queries about the database and provide explanations as to why or why not a particular answer (or query) is appropriate.

The book *micro-PROLOG* is essential for people who use the micro-PROLOG interpreter. The reference manual accompanying the micro-PROLOG 3.1 disk includes an excellent description of the system, utility modules, and other considerations for programmers (including how to add assembly-language subroutines to Prolog programs), but the manual recommends that the user work through

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BOOK REVIEWS

Clark and McCabe's book to learn the language.

The book claims to be a "self-instruction tutorial on logic programming using micro-PROLOG (version 3.1 or later) for someone unfamiliar with Prolog logic programming." The overall style and method of presentation are conducive to learning on your own, but the authors assume a certain degree of sophistication on the part of the reader. This book is indeed suitable for a reader unfamiliar with Prolog, but it is doubtful that a reader with little programming, mathematics, or linguistics background could easily follow much beyond the basic concepts presented in part I. Nonetheless, it is a fast-paced introduction to what computing can and should be like.

"Basic Concepts" introduces the foundations of Prolog: setting up a database of facts, formulating queries in the database, formulating rules (or conditional facts), arithmetic, and the key concepts of recursion and lists. Prolog is based on the concept of relations. A relation, mathematically speaking, is a set of "tuples," the individual elements of which come from different domains but are connected via some property.

The reader is led stepwise through key concepts by examples and exercises. The authors develop a "family" database with the relations father-of, mother-of, male, and female. They then discuss retrieving information from the database. Arithmetic operations (SUM, TIMES, LESS, and INT) are also considered relations by micro-PROLOG. Rules can be derived from relations to build still other relations. For example, parent-of can be derived from the relations father-of and mother-of, grandparent-of from parent-of, difference from SUM, etc. Clark and McCabe present these concepts thoroughly. They offer numerous examples and exercises to help solidify the learning process. Exercise sets are related to the text material, but each set of exercises leads the reader to discover more than just what was presented in the text. A reader seriously interested in mastering micro-PROLOG should work through all of the exercises in the book.

LISTS

The concept of list processing, which is central in artificial-intelligence research, is the main topic of "Logic Programming Using micro-PROLOG" in the second part. An interactive approach, where the user can input data to the program, is discussed along with functions, sorts, and more complex forms of conditions. The authors also discuss concatenation of lists and parsing.

The material just mentioned covers Prolog for the casual reader; the rest of part II is for the reader with some degree of sophistication. This is where the thrill of Prolog begins. Metaconditions, metaprograms, tail-recursive definitions, and user-created modules let you experience the full power of Prolog and, indeed, add to the built-in power of the micro-PROLOG supervisor. Again, the concepts are presented via numerous examples and exercises, but now they are of a more theoretical nature.

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	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
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BOOK REVIEWS

Part III is short (26 pages) and technical, showing mainly how to translate the SIMPLE sentence syntax (SIMPLE is a special syntax of micro-PROLOG that allows for a more English-like expression of sentences) used throughout the book into standard Prolog syntax. Little is new here aside from terminology and notation. A few features of micro-PROLOG that need standard syntax are included. This standard syntax, incidentally, is more like other versions of microcomputer Prolog, such as PROLOG-86. Someone familiar with SIMPLE Prolog would be able to use other versions of Prolog after mastering the concepts in this section.

The last part, "Applications of micro-PROLOG," is composed of four chapters written by guest authors to illustrate applications of micro-PROLOG. One chapter, by F. Kriwaczek, demonstrates an application of graph searching for project management. Kriwaczek develops a critical-path analysis program with explanations as to how Prolog is especially suited for this type of analysis.

The next chapter, entitled "micro-PROLOG of Expert Systems," was written by P. Hammond. It scans the development of a minicomputer expert system based on the medical system MYCIN, with particular emphasis on how Prolog lends itself to this type of system. The most interesting concept in this chapter is found in the explanations of how the system, if asked to explain its conclusions, can trace its own logic and provide the how and why of a particular conclusion.

"The Logic of Two-Person Games" by M. H. Van Emden and K. L. Clark is just good pure fun for anyone with a bias toward game theory. The authors provide an analysis of game trees and min-max principle, using Prolog relations (user-defined) such as good-move-for-white and value-of-white-to-move to develop winning strategy. Their discussion of chess-playing programs is very informative.

In the final chapter, "micro-PROLOG for Problem Solving," R. A. Kowalski and M. J. Sergot tackle all-purpose problem solving. Alternative search strategies and loop-detection techniques are incorporated as well. The only disappointment in this chapter was that it ended.

Required Reading

This book should be considered required reading for anyone interested in artificial intelligence, computer science, programming, or applied mathematics. Though learning the Prolog language is the main emphasis of the book, it is not really simplified.

In addition to examples and exercises mentioned earlier, "system notes" scattered throughout the text explain non-logic programming activities (such as starting up, interrupting a program run, executing a trace, and so on) that are not part of syntax but are certainly necessary if you are following along on a computer. Without a computer, you can still get a feel for programming in Prolog. The four applications chapters are excellently written and can help provide a feel for the full impact of this type of program-

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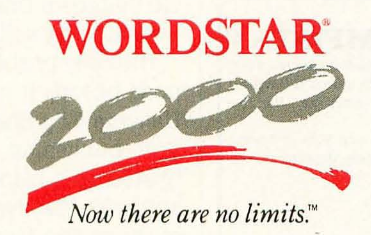
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ming. While perhaps not a book for self-teaching, *micro-PROLOG* is a standard model for textbooks on programming.

Margaret M. Sklar is an instructor in computer information systems at Northern Michigan University (Marquette, MI 49855). Her specialty is computer languages.

A SOFTWARE LAW PRIMER
Reviewed by Mark J. Welch

Many programmers know that a variety of legal questions need to be addressed before they can sell a program. Foremost is protection of the software itself since the programmer's goal is usually profit. Other issues, including potential liability to customers, obligations to previous employers, and contract law are less apparent but require consideration.

A *Software Law Primer* packs much useful information into a short, readable volume. I expected to find the usual analysis of methods of protecting software from being copied: copyrights, patents, trademarks, trade secrets, and licenses. Frederic W. Neitzke addresses each of these in brief detail and also deals with contracts, torts, and potential problems between employees and employers.

As explained in legal books and articles, protection for software is a fuzzy issue because laws covering patents, trademarks, copyrights, and trade secrets can all potentially protect software but not all at the same time. Neitzke suggests that while patents provide the strongest protection if upheld, they are too costly and uncertain for most programs. He explains how copyright, trade-secret, and trademark laws may be applied. Another chapter covers what must be done to be certain that specific protection will apply. The problems of contract and tort law, each of which could create unexpected liabilities for a company selling software, are also addressed.

In an industry with such a high turnover rate, employee/employer concerns need clarification. Neitzke identifies problems that could arise when an employee leaves a company, including concerns over trade secrets, ownership of general programming methods and tools, and the legality of some contract restrictions.

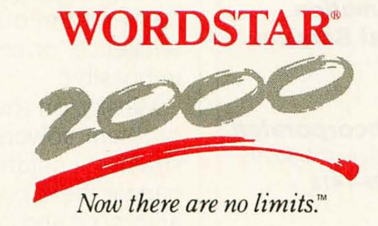
Throughout the book, Neitzke summarizes relevant cases and cautions that because the laws pertaining to software are still evolving, unexpected twists could occur. He suggests that a programmer consult a lawyer before considering selling software.

The only problem with this book is that only weeks need pass before it is out of date. The Betamax case (*Sony v. Universal City Studios*), which could have an effect on software publishing, was reversed by the Supreme Court shortly after this book was published. Despite the changes in software law, Neitzke's book provides an excellent summary of the issues confronting software entrepreneurs.

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Anyone hoping to make money from software should read *A Software Law Primer.*

Mark J. Welch is a staff writer for BYTE. *He can be contacted at* 425 Battery St., San Francisco, CA 94111.

EXTRATERRESTRIALS—SCIENCE AND ALIEN INTELLIGENCE
Reviewed by Jack D. Kirwan

A collection of 16 essays written by "some of the most distinguished philosophers and scientists of our generation," *Extraterrestrials—Science and Alien Intelligence* is a stunning summation of scholarly arguments, pro and con, on the question of other intelligences in the universe. Given that none of the contributors has ever seen an extraterrestrial, much of the book is based on speculation and extrapolation. The essays range from logical and ingenious exercises in reasoning to rather subjective anthropomorphism.

The academic contributors to *Extraterrestrials* include philosophers, biologists, mathematicians, and physicists. Personalities range from the relatively unknown to Carl Sagan and Marvin Minsky. The book is divided into five categories that cover "Existence and Nature of Extraterrestrial Intelligence," "Extraterrestrial Epistemology," "Where Are They?" "Detectability and Decipherability," and "Meaning and Consequences of Contact." The question of alien intelligence and existence is looked at from several vantage points.

In terms of dazzling ideas per square inch, almost every page has something worth quoting. Some of the concepts function like delayed-action mines: They go off hours or even days later. While each contributor deserves in-depth discussion, space permits mentioning only a few.

COMPUTER THEORY

Computer theory recurs sporadically throughout the book. However, sections in "Extraterrestrial Epistemology" and "Detectability and Decipherability" specifically address computers and the search for aliens. A philosophy professor, Nicholas Rescher, and artificial-intelligence pioneer Marvin Minsky discuss whether we can even communicate with aliens (assuming there are any). Rescher thinks not. He argues that in adapting to an environment completely distinct from our own, an alien may develop science, intelligence, or senses so different that communication is impossible.

Minsky, on the other hand, reasons that "all intelligent problem solvers are subject to the same ultimate constraints: limitations on space, time, and materials." To handle these constraints, they will perforce develop both arithmetic and language skills. Because arithmetic is based on universal truths, alien mathematics will be congruent to our own, Minsky says. And because life's realities are,

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in general, the same everywhere, our languages will match to a "degree that will enable us to communicate with them."

Interestingly, the astronomers, especially those of SETI (the Search for Extraterrestrial Intelligence), are generally optimists on the subject of extraterrestrials, while evolutionary biologists tend to be pretty dubious. Ernst Mayer, for example, considers SETI "a deplorable waste of the taxpayers' money."

Jill Tarter's essay "Searching for Extraterrestrials" applies the old analogy of searching for a needle in a haystack: How many haystacks are there? How long do they last? How should one look for a needle? (A magnet might miss a platinum one.) Tarter exemplifies that scientific reasoning need not be dull.

Cipher A. Deavours (one of the editors and founders of *Cryptologia*, a quarterly cryptology journal published in Lawrence, Kansas) has contributed a fascinating essay on using cryptology to solve the problem of communication with aliens. After all, many a top-drawer cryptographer can break a foreign code without knowing a word in the encoded language.

One essay that stands out is Hans Freudenthal's "Excerpts from *LINCOS: Design of a Language for Cosmic Intercourse*" (Amsterdam: North-Holland, 1960). This excerpt from the out-of-print classic covers the reasoning behind the development of the binary language LINCOS, which stands for *lingua cosmica*. LINCOS uses >, <, +, =, and – as vocabulary words and variables.

THE DEBATE

The heart of the book is part IV, "Where Are They?" The title originates from Enrico Fermi's well-known query: "If extraterrestrials really exist, where are they?" This section is a veritable scientific debate. Carl Sagan and William J. Newman clash ideas with Frank Tipler, a University of Texas physicist whose unequivocal piece is entitled "Extraterrestrial Beings Do Not Exist." Newman and Sagan (the father of SETI) call their reply "A Solipsist Approach to External Intelligence."

This debate could have been the most dramatic and interesting part of the book, but it is not. There is no contest. Tipler makes a very strong case for the anti-ET premise, while the Sagan/Newman response is disappointing in contrast.

Tipler's piece (originally published in 1980 in the *Quarterly Journal of the Royal Astronomical Society*) begins with the premise that "an intelligent species with the technology for interstellar communication would necessarily develop the technology for interstellar travel, and this would automatically lead to the exploration and/or colonization of the Galaxy in less than 300 million years."

Put briefly, Tipler argues that any species with the technology to send or receive communications would have made comparable advances in other fields, particularly rocketry. He reminds us that "it is a deficiency in com-

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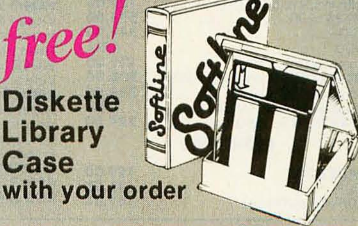
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puter technology, not rocket technology, which prevents us from beginning the exploration of the Galaxy tomorrow." Tipler then assumes that "a species will eventually develop a self-replicating universal constructor with intelligence comparable to our present-day technology, but which is comparable to the human level—such a machine should be developed within a century." This theoretical unit is known as a von Neumann machine. Tipler suggests that the sole problem of interstellar travel boils down to "transporting a von Neumann machine to another solar ystem." He figures that for a technologically advanced culture, "the exploration of the Galaxy would cost about 3 billion dollars, about one-tenth the cost of the Apollo program." This telescoped version of Tipler's argument contains only some key links in a long chain of reasoning.

I found the response to Tipler by Sagan and Newman (published in 1982) disappointing on several counts. For one thing, they figure "these implacable replicators will not stop until the entire Universe has been converted into $\sim 10^{47}$ von Neumann machines, which will then presumably cannibalize each other." (Tipler previously addressed this argument.) But the weakness of Sagan and Newman is that they weave their own prejudices into the argument. For example: "It seems to us quite unlikely that an advanced technological civilization, undergoing continued biological and psychological as well as scientific development, will persevere in such imperialist designs for a billion years" and "Civilizations devoted to territoriality and aggression and violent settlement of disputes do not long survive after the development of apocalyptic weapons. Long before they are able to make any colonization of the Milky Way, they are gone from the galactic stage."

I question how Sagan and Newman know all this. Though Sagan and Newman make valid points, much of their article is anthropomorphizing.

This is definitely not the case with Edward Regis, the editor of this book. His essay "SETI Debunked" examines a fairly common mindset, typified by those people who (consciously or not) favor SETI as a means of attracting Higher Beings who will beam down and save mankind from human follies. Regis's pro-human contribution is a highlight of the book.

All in all, the anti-ET people argue a more compelling case. This is not to say that they advocate playing ostrich and letting the rest of the galaxy go by, but they do point out that the odds are against SETI's success.

While I consider this book must reading for anyone interested in aliens in general or SETI in particular, *Extraterrestrials* deserves a wide audience. This collection of essays, even the comparatively weaker ones, is a tribute to the level of terrestrial reasoning possible with such sparse information. ■

Jack D. Kirwan is assistant editor of The Energy Journal, *produced by the Department of Economics at the University of Arizona in Tucson* (85721).

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7400

Part No.	Pins	Price
SN7400N	14	.29
SN7401N	14	.29
SN7402N	14	.29
SN7403N	14	.29
SN7404N	14	.35
SN7405N	14	.49
SN7406N	14	.59
SN7407N	14	.59
SN7408N	14	.29
SN7409N	14	.35
SN7410N	14	.29
SN7411N	14	.29
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.49
SN7417N	14	.59
SN7420N	14	.19
SN7421N	14	.59
SN7422N	14	.59
SN7423N	16	.69
SN7425N	14	.39
SN7426N	14	.39
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.35
SN7432N	14	.39
SN7433N	14	.49
SN7437N	14	.25
SN7438N	14	.49
SN7439N	14	.79
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.75
SN7447N	16	.75
SN7448N	16	.75
SN7454N	14	.19
SN7459N	14	.35
SN7460N	14	.39
SN7470N	14	.39
SN7472N	14	.39
SN7473N	14	.39
SN7474N	14	.39
SN7475N	16	.45
SN7476N	16	.39
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.55
SN7485N	16	.59
SN7486N	14	.39
SN7489N	16	2.25
SN7490N	14	.49
SN7491N	14	.79
SN7492N	14	.45
SN7493N	14	.45
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.45
SN74122N	14	.69
SN74123N	16	.55
SN74125N	14	.49
SN74126N	14	.49
SN74128N	14	.79
SN74132N	14	.59
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.65
SN74147N	16	1.29
SN74148N	16	.89
SN74150N	24	1.49
SN74151N	16	.49
SN74152N	14	.49
SN74153N	16	.99
SN74154N	24	1.49
SN74155N	16	.49
SN74156N	16	.59
SN74157N	16	.49
SN74159N	24	1.95
SN74160N	16	.59
SN74161N	16	.59
SN74162N	16	.59
SN74163N	16	.59
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.69
SN74167N	16	2.95
SN74170N	16	1.59
SN74172N	24	4.95
SN74173N	16	.85
SN74174N	16	.59
SN74175N	16	.59
SN74176N	14	.79
SN74177N	14	.79
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.05
SN74184N	16	2.29
SN74185N	16	2.29
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.49
SN74196N	14	.75
SN74197N	14	.75
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74273N	20	1.95
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.39
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

Part No.	Pins	Price
74LS00	14	.29
74LS01	14	.29
74LS02	14	.35
74LS03	14	.29
74LS04	14	.39
74LS05	14	.35
74LS08	14	.35
74LS09	14	.35
74LS10	14	.35
74LS11	14	.35
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.35
74LS26	14	.29
74LS27	14	.35
74LS28	14	.39
74LS30	14	.39
74LS32	14	.39
74LS37	14	.35
74LS38	14	.39
74LS42	16	.49
74LS47	16	.89
74LS51	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.45
74LS76	16	.39
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.59
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.45
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.59
74LS126	14	.59
74LS132	14	.65
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
74LS139	16	.59
74LS145	16	1.19
74LS147	16	1.95
74LS148	16	1.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.49
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.89
74LS165	16	.89
74LS168	16	1.19
74LS169	16	1.49
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.49
74LS190	16	.79
74LS191	16	.89
74LS192	16	.79
74LS193	16	.89
74LS194	16	.69
74LS195	16	.59
74LS196	14	.89
74LS197	14	.89
74LS221	16	1.09
74LS240	20	1.09
74LS241	20	.99
74LS243	14	1.09
74LS244	20	1.29
74LS245	20	1.49
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.49
74LS273	20	1.49
74LS279	16	.49
74LS280	14	1.95
74LS299	20	2.95
74LS322	20	3.95
74LS323	20	3.95
74LS347	16	.79
74LS353	16	1.09
74LS364	20	1.95
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.39
74LS393	14	1.19
74LS399	16	1.49
74LS490	16	1.95
74LS533	20	1.95
74LS534	20	1.95
74LS540	20	1.49
74LS541	20	1.49
74LS640	20	2.19
74LS641	20	2.19
74LS644	20	2.19
74LS645	20	2.19
74LS670	16	1.49
74LS688	20	2.95
81LS95	20	1.49
81LS96	20	1.49
81LS97	20	1.49
81LS98	20	1.49

74S/PROMS*

Part No.	Pins	Price
74S00	14	.35
74S02	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.45
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S37	14	.99
74S38	14	.89
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	1.99
74S86	14	.55
74S112	16	.55
74S124	16	2.75
74S132	14	1.89
74S133	16	.45
74S135	16	.89
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.69
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.29
74S169	16	4.29
74S174	16	1.09
74S175	16	1.09
74S188*	16	1.75
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	1.95
74S241	20	1.95
74S242	14	2.19
74S244	20	2.19
74S251	16	.99
74S253	16	.99
74S257	16	.99
74S258	16	.99
74S273	20	2.39
74S280	14	1.89
74S287*	16	1.79
74S288*	16	1.79
74S299	20	5.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	4.95
74S472*	20	4.95
74S473*	20	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95

74ALS

Part No.	Pins	Price
74ALS00	14	.59
74ALS02	14	.59
74ALS04	14	.59
74ALS08	14	.59
74ALS10	14	.59
74ALS30	14	.59
74ALS32	14	.65
74ALS74	14	.79
74ALS109	16	.79
74ALS112	16	.69
74ALS138	16	1.25
74ALS240	20	2.25
74ALS244	20	2.25
74ALS245	20	2.59
74ALS373	20	2.59
74ALS374	20	2.59

74F

Part No.	Pins	Price
74F00	14	.69
74F02	14	.75
74F04	14	.89
74F08	14	.75
74F10	14	.75
74F20	14	.69
74F32	14	.79
74F74	14	.85
74F86	14	1.15
74F109	16	.95
74F138	16	1.69
74F139	16	1.49
74F157	16	1.69
74F158	16	1.69
74F240	20	3.75
74F244	20	3.49
74F253	16	1.79
74F257	16	1.79
74F280	14	1.69
74F373	20	4.89
74F374	20	4.59
74F379	16	1.99

CD—CMOS

Part No.	Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4008	16	.89
CD4009	16	.59
CD4010	16	.49
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	.89
CD4015	16	.39
CD4016	14	.49
CD4017	16	.79
CD4018	16	.79
CD4019	16	.49
CD4020	16	.75
CD4021	16	.75
CD4022	16	.75
CD4023	14	.29
CD4024	14	.69
CD4025	14	.29
CD4026	16	1.59
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.79
CD4035	16	.79
CD4040	16	.75
CD4041	14	.69
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.89
CD4053	16	.79
CD4056	16	2.95
CD4059	24	3.95
CD4060	16	.89
CD4066	14	.45
CD4068	14	.39
CD4069	14	.35
CD4070	14	.29
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.89
CD4077	14	.35
CD4078	14	.49
CD4081	14	.29
CD4093	14	.49
CD4094	16	1.95
CD4098	16	1.95
CD4099	16	1.89
CD4503	16	.69
CD4506	16	1.29
CD4507	14	1.19
CD4508	24	1.95
CD4510	16	.85
CD4511	16	.85
CD4512	16	.85
CD4514	24	1.49
CD4515	24	1.49
CD4516	16	.89
CD4518	16	.89
CD4519	16	.59
CD4520	16	.89
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.69
CD4531	16	.89
CD4538	16	1.49
CD4541	14	1.49
CD4543	16	1.19
CD4566	16	2.95
CD4583	16	2.49
CD4584	14	.59
CD4585	16	1.39
CD4723	16	1.19
CD4724	16	1.19
MC14410	16	8.95
MC14411	24	11.95
MC14412	16	7.95
MC14433	24	17.95
MC14490P	16	4.95
MC14572	16	1.19

RED-HOT RAM & EPROM PRICES

Part No.	Description	Price
21C14	(200ns) CMOS SRAM CMOS USES LESS POWER	.99
27C16	(450ns) CMOS EPROM	9.95
4164N-200	(DRAM)	1.49-9/12.95
6116P-4	(200ns) SRAM	3.49
6116LP-4	(200ns) L.P. SRAM	3.69
6264P-15	(150ns) SRAM	6.95
6264LP-15	(150ns) L.P. SRAM	7.49
27128-25	(250ns) EPROM	5.95
41256-150	(150ns) DRAM	6.49
68764	(450ns) 21V EPROM	12.95
EWC-1	EPROM Window Covers	10/.69

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	16.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
Z80, Z80A, Z80B, Z8000 SERIES			
Z80	40	CPU (MK3880N)(780C) 2.5MHz	2.75
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	2.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	2.95
Z80A-CTC	28	Counter Timer Circuit	3.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
6500/6800/68000 SERIES			
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	5.25
6502B	40	MPU with Clock (3MHz)	7.95
6520	40	Peripheral Inter. Adapter	2.75
6522	40	Versatile Inter. Adapter	4.95
6551	28	Async. Comm. Interface Adapt.	6.95
6800	40	MPU	2.95
6802	40	MPU with Clock and RAM	5.95
6809	40	CPU — 8-Bit (On-Chip Oscillator)	6.95
6809E	40	CPU — 8-Bit (External Clocking)	8.49
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	11.49
6810	24	128x8 Static RAM	2.75
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.75
68B21	40	Peripheral Interface Adapter (2MHz)	4.95
6845	40	CRT Controller (CRTC)	9.95
68B45	40	CRT Controller (CRTC) 2MHz	14.95
6850	24	Asynchronous Comm. Adapter	2.95
6860	24	0-600bps Digital MODEM	6.95
68000L8	64	MPU 16-Bit (8MHz)	34.95
68488P	40	General Purpose Int. Adapter	9.95
68661	28	Enhanced Prog. Comm. Interface (2661)	8.95
8000/80000 SERIES			
8031	40	Control Oriented CPU w/RAM & I/O	12.95
8035	40	MPU — 8-Bit	4.95
8039	40	CPU—Sgl. Chip 8-Bit (128bts. RAM)	4.95
8040N-6	40	CPU (256 bytes RAM)	9.95
8060	40	CPU — 8-Bit NMOS	12.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	3.95
8085A-2	40	CPU-8-Bit N-Channel (5MHz)	10.95
8086-2	40	CPU 16-bit 8MHz	19.95
8087	40	Arithmetic Processor (5MHz)	129.95
8087-2	40	Arithmetic Processor (8MHz)	159.95
8088	40	CPU 8/16-Bit	14.95
8155	40	HMOS RAM I/O Port-Timer	4.95
8156	40	RAM with I/O Port and Timer	5.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.25
8224	16	Clock Generator/Driver	2.69
8228	28	Sys. Cont./Bus Driver (74S428)	3.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	12.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	3.95
8250N	40	Async. Comm. Element	9.95
8251	28	Prog. Comm. I/O (USART)	3.25
8251A	28	Prog. Comm. Interface (USART)	3.49
8253-5	24	Prog. Interval Timer	6.49
8255	40	Prog. Peripheral I/O (PPI)	3.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	4.25
8257-5	40	Prog. DMA Controller	6.95
8259	28	Prog. Interrupt Control	5.95
8259-5	28	Prog. Interrupt Controller	6.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	16.95
8274	40	Multi-Protocol Serial Cont. (7201)	14.95
8275	40	Prog. CRT Controller	14.95
8279	40	Prog. Keyboard/Display Interface	5.49
8279-5	40	Prog. Keyboard/Display Interface	5.95
8282	20	Octal Latch	6.49
8284	18	Clock Generator/Driver	5.49
8286	20	Octal Bus Transceiver	6.49
8287	20	Octal Bus Transceiver (Inverted)	6.49
8288	20	Bus Controller	13.95
8289	20	Bus Arbiter	24.95
8741	40	8-Bit Univ. Peripheral Interface	19.95
8748	40	HMOS EPROM MPU	19.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	24.95
8755	40	16K EPROM with I/O	39.95
80186-6	68	High Integration 16-Bit MPU	49.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	49.95
SPECIAL FUNCTION			
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	1.49
4116N-15	16	16,384x1	(150ns)	1.39 — 8/10.95
4116N-20	16	16,384x1	(200ns)	.79-8/6.29
4116N-25	16	16,384x1	(250ns)	.69-8/5.49
4164N-150	16	65,536x1	(150ns)	1.65 — 9/14.49
4164N-200	16	65,536x1	(200ns)	1.49 — 9/12.95
MM5261	18	1024x1	(300ns)	.35 — 8/1.95
MM5262	22	2048x1	(365ns)	.35 — 8/1.95
MM5270	18	4096x1	(250ns)	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5298-3	16	8192x1	(200ns)	.59
41256-150	16	262,144x1	(150ns)	6.49
41256-200	16	262,144x1	(200ns)	5.95
4128	16	131,072x1	(250ns)	14.95
STATIC RAMS				
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
2102-2L	16	1024x1	(250ns) L.P. (91L02)	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114N	18	1024x4	(450ns)	1.29 — 8/9.95
2114N-L	18	1024x4	(450ns) L.P.	1.65 — 8/12.95
2114N-2	18	1024x4	(200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4	(200ns) L.P.	1.69 — 8/13.49
2147HN	18	4096x1	(70ns)	4.49
2148HN	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	2.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-2	24	2048x8	(120ns) CMOS	4.95
HM6116LP-2	24	2048x8	(120ns) L.P. CMOS	6.49
HM6116P-3	24	2048x8	(150ns) CMOS	3.75
HM6116LP-3	24	2048x8	(150ns) L.P. CMOS	3.95
HM6116P-4	24	2048x8	(200ns) CMOS	3.49
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	3.69
HM6264P-12	28	8192x8	(120ns) CMOS	7.25
HM6264LP-12	28	8192x8	(120ns) L.P. CMOS	7.95
HM6264P-15	28	8192x8	(150ns) CMOS	6.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	7.49
27LS00	16	256x1	(80ns) L.P.	3.95
7489	16	16x4	(50ns) 3101	2.25
74C921	18	256x4	(250ns) CMOS	5.95
74C930	18	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25
PROMS/EPROMS				
1702A	24	256x8	(1μs)	3.95
TMS2516	24	2048x8	(450ns)	4.95
TMS2532	24	4096x8	(450ns)	5.49
TMS2564	28	8192x8	(450ns)	10.95
2708	24	1024x8	(450ns)	3.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	9.95
2716-1	24	2048x8	(350ns)	4.95
2716Q-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.25
2732A-20	24	4096x8	(200ns) 21V	9.95
2732A-25	24	4096x8	(250ns) 21V	5.95
2732A-45	24	4096x8	(450ns) 21V	4.49
27C32	24	4096x8	CMOS	11.95
27C32A-30	24	4096x8	(300ns) 21V (CMOS)	22.95
2764-20	28	8192x8	(200ns) 21V	6.95
2764-25	28	8192x8	(250ns) 21V	5.09
2764-45	28	8192x8	(450ns) 21V	4.95
27C64	28	8192x8	CMOS 21V	11.95
27128-25	28	16,384x8	(250ns) 128K 21V	5.95
27256-25	28	32,768x8	(250ns) 256K (14V)	19.95
MCM68764	24	8192x8	(450ns) 21V	12.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

Part No.	Pins	Function	Price
DC10		Mostek DC/DC Converter +5V to −9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)	4.49
DAC1000	24	10-Bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1022	16	10-Bit D/A Conv. (0.20% lin.)	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-3-1015D	40	25K Baud UART	4.25
AY-5-1013A	40	30K Baud UART (TR1602)	3.95

Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

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Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

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Part No.	1-9	10-99	100-up
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INTERSIL

Part No.	Pins	Function	Price
FE0202D	40	4 Digit LCD Display for 7211IPL & 7211MIPL	14.95
FE0203D	40	3½ Digit LCD Display for 7106 & 7116	14.95
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IUS		Low Battery Volt. Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7211IPL	40	4 Digit LCD Display Decoder/Driver (TTL compatible)	7.95
7211MIPL	40	4 Digit LCD Display Decoder/Driver (Microproc. compat.)	8.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit)	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
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7226AEV/Kit	40	5 Function Counter Chip, XTL (Evaluation Kit)	99.95

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74HC HIGH SPEED CMOS

Part No.	Pins	Price
74HC00	14	.59
74HC02	14	.59
74HC03	14	.89
74HC04	14	.59
74HCU04	14	.69
74HC08	14	.59
74HC10	14	.59
74HC11	14	.69
74HC14	14	.89
74HC20	14	.59
74HC27	14	.59
74HC30	14	.69
74HC32	14	.79
74HC42	16	1.09
74HC51	14	.89
74HC58	14	.89
74HC73	14	.79
74HC74	14	.79
74HC75	16	.99
74HC76	16	.79
74HC85	16	1.69
74HC86	14	.75
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC123	16	2.29
74HC125	14	1.75
74HC132	14	1.29
74HC137	16	1.59
74HC138	16	1.19
74HC139	16	1.05
74HC147	16	1.29
74HC151	16	.99
74HC153	16	1.09
74HC154	24	2.65
74HC157	16	.99
74HC158	16	.99
74HC160	16	1.39
74HC161	16	1.39
74HC162	16	1.39
74HC163	16	1.39
74HC164	14	1.35
74HC165	16	2.15
74HC166	16	2.49
74HC173	16	1.29
74HC174	16	1.09
74HC175	16	1.09
74HC190	16	1.59
74HC191	16	1.59
74HC192	16	1.49
74HC193	16	1.49
74HC194	16	1.19
74HC195	16	1.19
74HC221	16	2.95
74HC237	16	1.49
74HC240	20	2.29
74HC241	20	2.29
74HC242	14	2.15
74HC243	14	2.15
74HC244	20	2.29
74HC245	20	2.59
74HC251	16	.99
74HC253	16	1.09
74HC257	16	.99
74HC259	16	1.69
74HC266	14	.89
74HC273	20	2.79
74HC280	14	4.59
74HC299	20	5.59
74HC366	16	2.59
74HC367	16	2.59
74HC373	20	2.69
74HC374	20	2.69
74HC390	16	1.59
74HC393	14	1.59
74HC533	20	2.69
74HC534	20	2.69
74HC595	16	3.19
74HC688	20	3.59
74HC4024	14	1.75
74HC4040	16	1.49
74HC4049	16	.89
74HC4050	16	.89
74HC4060	16	1.49
74HC4075	14	.59
74HC4078	14	.59
74HC4511	16	1.95
74HC4514	24	4.19
74HC4538	16	2.59
74HC4543	16	3.75

74HCU04 is unbuffered -

74C—C/MOS

Part No.	Pins	Price
74C00	14	.29
74C02	14	.35
74C04	14	.35
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.19
74C48	16	1.79
74C73	14	.69
74C74	14	.59
74C85	16	1.39
74C86	14	.29
74C89	16	5.95
74C90	14	1.09
74C93	14	1.09
74C95	14	1.19
74C107	14	.79
74C151	16	2.19
74C154	24	3.25
74C157	16	1.75
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.29
74C165	16	1.29
74C173	16	.89
74C174	16	1.19
74C175	16	1.19
74C192	16	1.39
74C193	16	1.39
74C195	16	1.29
74C221	16	1.75
74C240	20	1.95
74C244	20	1.95
74C373	20	2.29
74C374	20	2.29
74C901	14	.59
74C902	14	.79
74C903	14	.59
74C906	14	.59
74C907	14	.89
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

Part No.	Pins	Price
DS0026CN	8	1.95
TL071CP	8	.79
TL072CP	8	1.09
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM109K		5.95
LM301CN	8	.39
LM302H		2.49
LM304H		1.95
LM305H		.99
LM307CN	8	.49
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.95
LM311CN	8	.59
LM312H		2.79
LM317T		1.19
LM317K		3.49
LM318CN	8	1.59
LM319N	14	1.49
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.85
LM320T-12		.85
LM320T-15		.85
LM320T-24		.85
LM322N	14	1.49
LM323K		4.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.29
LM336Z		1.09
LM337MP		1.15
LM337T		1.89
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.75
LM340T-12		.75
LM340T-15		.75
LM340T-24		.75
LF347N	14	1.49
LM348N	14	.89
LM350K		4.79
LF351N	8	.59
LF353N	8	.89
LF355N	8	1.09
LF356N	8	1.09
LM358N	8	.59
LM359N	14	1.79
LM370N	14	4.95
LM373N	14	4.95
LM377N	14	1.95
LM380CN	8	1.09
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.49
LM384N	14	1.95
LM386N-3	8	.89
LM387N	8	1.39
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.59
LM393N	8	.45
LF398N	8	3.95
LM399H		5.95
LF412CN	8	1.95
TL494CN	16	2.79
TL496CP	8	1.59
NE531V	8	1.79
NE540H (C540H)		2.95
NE544N	14	1.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.69
LM556N	14	.79
NE558N	16	1.59
NE564N	16	1.95
LM565N	14	.99
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	2.95
NE571N	16	2.49
NE592N	14	1.19
LM703CN	8	1.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.49
LM733N	14	.89
LM739N	14	1.95
LM741CN	8	.39
LM747N	14	.69
LM748N	8	.59
UA760HC		9.95
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	.99
LM1605CK		9.95
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.95
LM1889N	18	1.95
LM1896N	14	1.59
LM2002T		1.95
ULN2003A	16	1.49
XR2206	16	3.95
XR2207	14	2.49
XR2208	16	1.79
XR2211	14	2.95
LM2877P		1.95
LM2878P		2.95
LM2901N	14	.79
LM2902N	14	.89
LM2907N	14	2.49
LM2917N	8	1.95
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.89
LM3914N	18	2.39
LM3915N	18	2.39
LM3916N	18	2.39
RC4136N	14	1.25
RC4151NB	8	1.95
RC4193NB	8	1.95
RC4195TK		5.95
LM4250CN	8	1.49
NE5532	8	1.69
NE5534	8	1.39
78L05A		.39
78L12A		.39
79L05A		.59
79M05AH		1.29
ICL8038	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19
75477	8	.99
76002	14	1.95
76477	28	3.95

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TRS-16K3 200ns (Model III). $6.29
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TRS-64K-2. . . . . $17.95

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• TRS-80 Model 100* • NEC • Olivetti

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Easy to install module plugs right into the socket increasing memory in 8K increments. Complete with module and documentation for conversion.

M1008K (TRS-80 Model 100 Expansion). **$49.95**
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Intelligent 300/1200 Baud Modem with Real Time Clock/Calendar

The ProModem™ is a Bell 212A (300/1200 baud) intelligent stand-alone modem • Full featured expandable modem • Standard features include Auto Answer and Auto Dial, Help Commands, Programmable Intelligent Dialing, Touch Tone™ & Pulse Dialing and More • Hayes command set compatible plus an additional extended command set • Shown w/alphanumeric display option.

PM1200 RS-232 Stand-Alone Unit. $299.95

OPTIONS FOR ProModem 1200

PM-COM (ProCom Communication Software). **$79.95**
Please specify Operating System.
PM-OP (Options Processor). **$79.95**
PMO-16K (Options Processor Memory – 16K). . . . . **$ 4.50**
PMO-32K (Options Processor Memory – 32K). . . . . **$ 9.00**
PMO-64K (Options Processor Memory – 64K). **$18.00**
PM-ALP (Alphanumeric Display). **$79.95**

PM-Special (Incl. Options Processor, 64K Memory and Alphanumeric Display). **$149.95**

DATA BOOKS





30009	Intersil Data Book (1984). . . . . Complete Line (965 pages).	$9.95
30013	Zilog Data Book (1984). . . . . Microprocessors and Support Chips (849 pages).	$9.95
210830	Intel Memory Components Hndbk. (1983/84). . . . Contains all Applications Notes, Article Reprints, Data Sheets & other design information on Intel's RAMs, DRAMs, EPROMs, E²PROMs and Bubble Memories (880 pages).	$14.95
230843	Intel Microsystem Components Hndbk. (1983/84) Contains Data Sheets on all of Intel's Microprocessors & peripherals – 2 volumes (2575 pages).	$19.95
30022	National Logic Data Book Set (1984). . . . . Volumes I & II (3485 pages). Contains information on National's TTL product line and CD4000 family. This includes 7400, 74L, S, AS, LS and ALS Series devices, and MM54HC / 74HC / 54HCT / 74HCT High Speed Micro CMOS family, MM54C / 74C family, and CMOS LSI / VLSI.	$24.95

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b = Apple *IIe*

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ARC-16K. $39.95

Z-80 CP/M Card

The AZ80-1 is Soft-card compatible. Used with CP/M related programs. Software not included. Key: (a,b)

AZ80-1. . . . . $49.95

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The AEB-2 allows user to program and work with standard EPROMs (2716, 2732 & 2764). Easy to use, on-board firmware. Menu contains the following options: Write, Read, Copy, Compare, Blank-Check and Monitor. Complete with instructions. Key: (a,b)

AEB-2. . . . . $69.95

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The A80-C is an 80-column card designed for the Apple* II and II+ computers. The card is equipped with a soft switch which allows easy hookup for any monitor. The A80-C also features inverse video capabilities. This card is similar to the Videx*** 80 column card. Complete with instructions. Key: (a)

A80-C. $74.95

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The ASSC-P is a serial card with a printer mode. It generates standard RS-232C signals and is similar to the Apple* Super Serial Card. Complete with instructions. Key: (a,b)

ASSC-P. $99.95

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The APC-64K is a parallel graphics printer card with a 64K buffer and graphic dump capabilities. Complete with instructions. Key: (a,b)

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Extended 80-Column/64K RAM Card expands memory by 64K to give 128K when used with programs like VisiCalc™. Complete with instructions. Key: (b)

JE864. . . . . $79.95

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**VisiCalc is a registered trademark of Visi Corp. Inc. ***Videx is a registered trademark of Videx Inc.

APPLE™ Compatible 5¼" Half-Height Disk Drive



• Uses Chinon Pinch-type mechanics • 143K formatted storage • 35 tracks • Super quiet • Works with Apple Controllers or other compatibles (ACC-1) (left) • Complete with connector – just plug into your controller • Size: 5¾"W x 1⅝"H x 8"D • Wt.: 4 lbs. Key: (a,b)

ADD-12. . . . . $129.95

APPLE™ Compatible 5¼" Disk Drive & Controller Card

• Uses Shugart SA390 mechanics • 143K formatted storage • Color matches Apple Computer • Works with Apple Controller or other Apple-compatible controllers (ACC-1) • Complete with connector – just plug into your disk controller card • 35 tracks • Size: 6"W x 3½"H x 8-9/16"D • Wt.: 4¼ lbs. Key: (a,b)

ADD-514 (Disk Drive). **$149.95**
ACC-1 (Controller Card). . . . . **$ 49.95**

APPLE™ *IIc* Compatible 5¼" Half-Height Disk Drive

• Same specs as ADD-12 (left) except no controller necessary.

ADD-IIc. $129.95

Additional Apple* Compatible Products

APF-1	Cooling Fan with surge protection • Key: (a,b).	**$ 39.95**
JE614	Numeric/Aux. Keypad–23 accessible functions • Key: (b). . . .	**$ 49.95**
EAEC-1	Expanded Apple Enclosure Case only • Key: (a).	**$ 59.95**
KHP4007	Switching Power Supply • Key: (a).	**$ 59.95**
KB-A68	68-Key Apple Keyboard only • Key: (a).	**$ 79.95**
MON-12G	12" Green Monitor with swivel stand • Key: (a, b & *IIc*).	**$ 79.95**
JE520AP	Voice Synthesizer – Plug-in, User Ready • Key: (a,b).	**$119.95**
KB-EA1	Apple Keyboard and Case • Key: (a).	**$134.95**
PM1200A	Prometheus Internal Modem – 2 cards • Key: (a,b).	**$299.95**
PM1200M	Prometheus Macintosh Ext. Modem • Key: (Macintosh).	**$369.95**

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Power/Mate Corp. REGULATED POWER SUPPLY

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Part No.	Output	Size	Weight	Price
EMA5/6B	5V@3A/6V@2.5A	4⅞"Lx4"Wx2⅛"H	2lbs.	$29.95
EMA5/6C	5V@6A/6V@5A	5⅝"Lx4⅞"Wx2⅞"H	4lbs.	$39.95

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• Ideal for disk drive needs of CRT terminals, microcomputers and video games • Input: 115/230VAC, 50/60Hz • Output: +5V @ 5A, +12V @ 1.8A, +12V @ 2A, –12V @ 0.5A • UL recognized • CSA certified • Size: 7⅜"L x 6-3/16"W x 1⅝"H • Weight: 2 lbs.

MRM 174KF. $49.95



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• Microprocessor, mini-computer, terminal, medical equipment and process control applications • Input: 90-130VAC, 47-440Hz • Output: +5VDC @ 5A, –5VDC @ 1A; +12VDC @ 1A, –12VDC @ 1A • Line regulations: ±0.2% • Ripple: 30mV p-p • Load regulation: ±1% • Overcurrent protection • Adj: 5V main output ±10% • Size: 6⅜"L x 1⅞"W x 4-15/16"H • Weight: 1½ lbs.

FCS-604A. $69.95

$10 Minimum Order – U.S. Funds Only **CA Residents: Add 6½% Sales Tax** **Spec Sheets – 30¢ each**
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IBM PC AT

Each kit comes complete with nine 128K dynamic RAMs and documentation for conversion.

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The ProModem 1200B/BS is a 1200/300 baud modem card which plugs into IBM PC and XT. Provides a third serial Comport. Two versions available: 1200B (without software) and 1200BS (with software). The PM1200BS is supplied with powerful MITE communications software from Mycroft labs.

PM1200B (without Software). **$239.95**
PM1200BS (with MITE Software). **$274.95**

IBM Compatible! DISK DRIVES

Documentation Included

RFD480 (Remex 5¼" DS full-ht.). . . . . **$ 89.95**
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SA455 (Shugart 5¼" DS half-ht.). . . . **$139.95**
TM100-2 (Tandon 5¼" DS full-ht.). **$159.95**

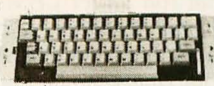
5¼" DISK DRIVE ENCLOSURES

Complete with power supply, switch, power cord, fuseholder and connectors

DDE-1FH (Houses 1 full-ht. 5¼" drive). **$69.95**
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General Application Keyboards

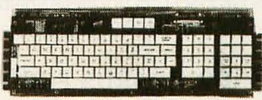
Mitsumi 54-Key Unencoded All-Purpose Keyboard



• SPST keyswitches • 20 pin ribbon cable connection • Low profile keys • Features: cursor controls, control, caps (lock), function, enter and shift keys • Color (keycaps): grey • Weight: 1 lb. • Pinout incl. • Size: 13⅛"L x 4¼"W x ¾"H

KB54. . . . . $14.95

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• 7-bit parallel ASCII • Full Upper Case, Full Lower Case except l, m, n, o and p. • Cursor keypad • SPST mechanical keyswitches • 26-pin header connector • Color: white • Size: 18"L x 6¼"W x 1¼"H • Spec included

KB8201. . . . . . *(1700 available)*. $29.95

UV-EPROM ERASER



Erases all EPROMs. Erases up to 8 chips within 21 minutes (1 chip in 15 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact – only 9.00"L x 3.70"W x 2.60"H. Complete with holding tray for 8 chips.

DE-4 **UV-EPROM Eraser. $74.95**
UVS-11EL **Replacement Bulb. $16.95**

A·S·K B·Y·T·E

Conducted by Steve Ciarcia

80186 C Machine

Dear Steve,

I'm interested in building a 16-bit C machine based on one of the Intel 80186 chips. Does anyone offer instructions or a kit? Is a suitable C available in ROM?

John A. Zook
Tempe, AZ

I haven't seen any kits for 80186-based computers, but I did locate an S-100 board. It is the Thunder 186 from Lomas Data Products (66 Hopkinton Rd., Westborough, MA 01581, (617) 366-6434).

There are also a couple of S-100 boards available using the 80286:

MI-286 S-100 board from
Macrotech International Corp.
9551 Irondale Ave.
Chatsworth, CA 91311
(818) 700-1501

CompuPro CPU 286/287 board from
Viasyn
3506 Breakwater Court
Hayward, CA 95455
(415) 768-0909

The CompuPro board is also available as part of the System 816/F computer, which runs CP/M. There are C compilers that run under CP/M-86 available from Digital Research, Microsoft, Mark Williams, and c-systems. Addresses of these companies can be found in ads in BYTE.

The Macrotech board runs MP/M 8/16 and other operating systems. It reportedly replaces the CompuPro 8085/88 board, so C compilers should be available from the above suppliers.—Steve

S-100 Boards for Horizon

Dear Steve,

I am writing for myself and for North Star Horizon users in general. Every day I notice ads for S-100/IEEE-696 boards. Many whet my appetite, but I become discouraged when I remember that my Horizon does not follow the IEEE-696 standard.

Selling my system to buy another computer that does conform to the IEEE-696 standard seems like a waste of good money.

How different is the Horizon's bus from the IEEE-696 standard? Is it possible to alter the bus lines to conform? Where can I get technical information for altering the bus, if it is feasible?

Jeff Chadima
Austin, TX

The Horizon remains a popular S-100 machine. North Star thought that demand would decline when the Advantage was introduced a few years ago, but such was not the case.

It is true that the Horizon does not completely follow the IEEE-696 standard. However, it is very close, and most S-100 boards should work in it without modification. I have used boards (some claiming IEEE-696 compatibility) from six manufacturers in the Horizon with no changes. The pin-outs used in the Horizon are detailed in the Horizon manual.

INSUA (International North Star User's Association, POB 2910, Fairfield, CA 94533) publishes The Compass *quarterly ($20 per year) for its members. Vol. IV.1 contains an article about various "alien" boards being used in the Horizon and notes incompatibilities, if any. They also have a former North Star technician who writes a regular column, answering questions about specific problems.*

Although now defunct, Microsystems *magazine (from Ziff-Davis) had a regular column on North Star topics. You might check your local library or computer club for back issues.*—Steve

An 8087 on the Sanyo MBC 555

Dear Steve,

I recently purchased a Sanyo MBC 555 microcomputer and find it to be everything I want in a computer. The review in the August 1984 BYTE (page 270) stated that the Sanyo had a slot for (and was configured for) the 8087 mathematics coprocessor. What does the 8087 do for the computer, and is it a wise investment for a small accounting practice?

William Cornelison
Ogdensburg, NY

The 8087 coprocessor is a special-purpose computer chip designed to perform certain arithmetic operations at high speed, under the control of an 8088 or 8086 processor. Its functions, which include floating-point addition, subtraction, multiplication, and division; square root, tangent, and arctangent; and log and exponential in base 2, are coded into the chip hardware to make for very fast execution. It has no effect on the speed of disk data transfer or other I/O operations.

The usefulness of the 8087 for your accounting applications depends on whether you need faster computational speed from your computer and on whether the 8087 will be used by your software. Most commercial business software is not written to look for an 8087 and will ignore it if present. The computer does not automatically use the 8087; special instructions are required at the machine-language level.

If you have software that will use the 8087, you can gain considerable speed in computation-intensive operations. Speed gains of up to 10 times have been reported in some cases, with 2 to 3 times being more typical.—Steve

Uninterruptible Power Supply

Dear Steve,

I live on a houseboat, and it seems to me that I already have half of an uninterruptible power supply in the boat. The boat has two engines and a generator, with a battery for each. One of the batteries is oversize and powers the toilet, running lights, and so on. The other batteries are used only for starting the engine.

The boat spends almost all its time at the dock, where the marina power is none too steady. I have a Raritan Crown automatic marine converter (20 amperes) that keeps the batteries constantly charged. The converter also works at anchor with the generator running.

It seems that if I got an inverter large enough to handle my IBM PC, I'd have an uninterruptible power supply. Is this true?

Steve Beste
Washington, DC

Two types of uninterruptible or back-

(continued)



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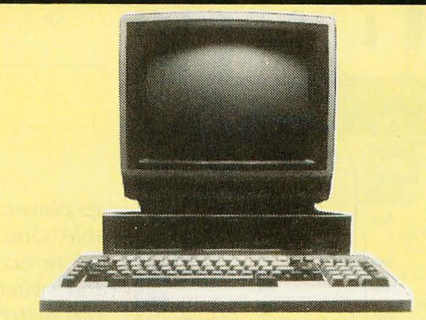
Our new Zorro AT systems give you: an 80286 CPU operating at a quick 6 Mz., eight expansion slots, a clock/calendar with battery backup, a 1.2 Megabyte 5 1/4" floppy disk drive, and IBM-AT compatibility.

Zorro AT's also come with a 360K drive for PC/XT media compatibility and 512K of RAM, features that would cost you hundreds of dollars from big blue.

Zorro AT-20's feature a 20 Mb. Winchester drive from NEC, and you still have room to add a fourth drive or tape backup.

To be quite frank, we believe our Zorro AT's are built better, and we back each system with a limited warranty for a full year. Our quality and features invite comparison, our prices speak for themselves.

Zorro AT	$2995
Zorro AT-20	$3995



The Silver Fox™ Trots Through Lotus Like 1,2,3

The Silver Fox is not IBM-PC compatible yet it runs hundreds of MS-DOS programs including Lotus 1,2,3, dBASE II, Multiplan, and even Flight Simulator.

The Silver Fox does not have IBM compatible expansion slots but you can economically add printers, serial ports, modems, 10-40 Mb. hard disks, clock/calendar cards, RAM, joysticks, an 8087 co-processor, and more.

What makes the Silver Fox unique, however, isn't what you can add to it, but what comes with it. Each Silver Fox comes with an 8088 CPU, 256K of RAM, four video ports, and a printer port. Plus you get more than twice the storage of a standard PC, 1.6 Megabytes on dual 5 1/4" floppys, and the Fox will read and write to standard 160K, 320K, and 360K IBM-PC formats.

Standard equipment also includes a better keyboard, a 12" high resolution monitor with a full 25x80 display, and we back each Silver Fox with a one year limited warranty.

Were this not enough each Silver Fox comes with the best free software bundle in the business including: MS-DOS 2.11/HAGEN-DOS 2.11, DOS Tutor, Wordstar 3.3, Easy Writer, Spell, Mail Track, PC File III, FILEBASE, CalcStar, games, graphics, utilities, and two BASIC languages.

Because computer sales usually slow down during the summer we've given you an extra incentive to buy a Fox by lowering our prices. If you want to get the most for your computer dollar, call our machine at 1-800-FORAFOX, leave your name and address at the beep, and we'll send you a Silver Fox booklet that will tell you how it can.

Silver Fox	$1297
Color Fox	$1497



Altos

High-performance, Xenix-based, multi-user systems from Altos-world leaders in multi-user systems and applications software.

As part of TRW's marketing support group we can have your Altos system installed on your site (additional charge).

Altos systems are easy to expand, and with shared printers and hard disks are cost competitive with multiple single user systems. Call for additional pricing and availability.

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586-40	$7249
986-40	$8829
Altos Acc't	$2779

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- Hard disk capacity and performance
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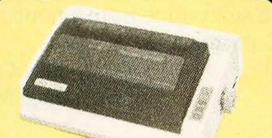
10 Mb	$1839
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8088•Dual 360K Drives
128K•Keyboard•Software
$899

Columbia 4220 or 2220 .... $1698

PRINTERS



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LX-80	~~$299~~ $60 off
Okidata 182	~~$299~~ $74 off
Okidata 192	~~$499~~ $125 off
Olympia NP	$329
Panasonic 1091	$269
Citizen MSP-10	$295
Toshiba 1340	$579
Toshiba 351	$1198

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Juki 6300	$719
Silver Reed 500	$299
Silver Reed 550	$409
Silver Reed 770	$724
Diablo	Call
NEC	Call
Daisywriter 2000	$824

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DMP-40	$745
DMP-41	$2340
other models	Call



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TERMINALS

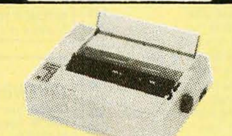


Qume VT101	$298
Wyse 50	$449

1200 BPS Modems

Volksmodem 12	$199
Password	Call
Prometheus	$315
Hayes 300/1200	$389

OLYMPIA



IS IT SICK TO LOVE A PRINTER?

If you love your Okidata 92 or Epson FX80 don't read any further because the new Olympia NP is rated as faster, is noticeably quieter and has a near letter quality mode that is much superior to anything in its price class.

Plus, unlike the Okidata or the Epson the Olympia comes with adjustable tractor feed (as well as friction feed) as standard equipment. The tractor feed is the "punch-type" and the NP has a tear bar so that it works great with continuous forms.

The NP uses standard Epson type ribbons, comes with the quality that has made Olympia world leader in typewriters and is backed by nationwide service.

To quote PC magazine, "The (NP) printer is a sure thing if it falls into your price range and even if it doesn't it may be worth considering . . ."

If you're considering the purchase of an Okidata, an Epson, or even a Toshiba, give us a call and let us send you an actual print sample from the Olympia NP and additional information.

Because if you were to buy an Epson FX-80 or an Okidata 92 with tractors and a cable for the lowest advertised prices, you would pay about $50 more for an inferior printer. Scottsdale Systems sells the Olympia NP with a 10' shielded cable for a mere:

$344

up power supplies are commonly available. One type is inactive until a power failure occurs. It senses the power loss and switches in to power your system. The switch takes a few milliseconds and usually doesn't appear as an interruption to the computer.

The other type supplies power to the computer at all times and might be more suitable for your situation. This type effectively runs your computer off its internal batteries at all times and provides excellent isolation from power-line transients. Both types maintain fully charged batteries by taking power from the line as needed. Some make provisions for external batteries, as you require for extended operation.

Some vendors of on-line uninterruptible power supplies are

Electronic Protection Devices
41 Montvale
Stoneham, MA 02180
(617) 890-2518

General Power Systems
1400 North Baxter St.
Anaheim, CA 92806
(714) 956-9521

Jefferson Electric
840 25th Ave.
Bellewood, IL 60104
(312) 544-2200

RTE Deltec
2727 Kurtz St.
San Diego, CA 92110
(619) 291-4211

—Steve

IBM PC RS-232C

Dear Steve,

Before I purchased my IBM PC, I owned a Qume Sprint 5 printer. By trial and error, I created a usable but not fully satisfactory cable to connect this serial printer to the IBM serial board. Apart from identifying pin usage and furnishing general suggestions, neither IBM nor Qume can help me. I am using an intelligent interface, but I would prefer to have a real cable. Is there a source that specifies proper computer-to-printer interfaces?

FREDERICK ORKIN
Philadelphia, PA

Your problem is not uncommon. Despite the reputation that RS-232C has as a standard, it really hasn't helped end the confusion about printer interfacing.

There are a few solutions, however. IQ Technologies (11811 Northeast First St., Bellevue, WA 98005, (206) 451-0232) sells a smart cable that lets you hook up RS-232C devices to your machine without worrying about what signal is on what pin. LEDs on the device indicate which direction two switches on the cable must be set to ensure proper handshaking. The price is $89.

Another possibility is to use a breakout box (available from many manufacturers, priced from about $40 to $80). This device slips between your computer and printer. It has LEDs that monitor the status of the various RS-232C lines so that you can actually "see" which lines are active. Some models provide jumpers so you can experiment with different connections until you determine the correct configuration.

For a complete description of the operation of breakout boxes and a circuit for the construction of one, see my article on page 28 of the April 1983 BYTE, "Build an RS-232C Breakout Box."—Steve

CHAINING BASIC PROGRAMS

Dear Steve,

Frequently, I use the CHAIN command in BASIC to chain two smaller programs together. How can I chain two already-compiled BASIC programs?

If I write two BASIC programs, what statements do I need to include, before compiling, to make one of the programs act as a subroutine of the other?

Is it possible to call a compiled BASIC program as a subroutine from a noncompiled BASIC program?

SEN CAN
St. Louis, MO

Two previously compiled BASIC programs cannot be chained without recompiling the source code and including the appropriate statements. An accomplished assembly-language programmer with a good debugging program could probably identify the "return to operating system" call in the first program. The programmer could then patch in a machine-language routine to chain to the second program, but it would be impossible to pass variables between the two programs.

Microsoft BASIC does not allow you to make a compiled BASIC program act as a subroutine to another program. However, a new product called BetterBASIC (Summit Software Technology, Box 99, Babson Park, Wellesley, MA 02157, (617) 235-0729) allows something similar. Read "IBM Images" in the December 1984

(continued)

Circuit-Board-Artwork Software for the Design Engineer in a Hurry

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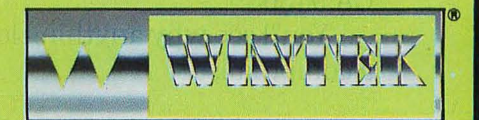
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issue of Creative Computing *for more details.*

It is not possible to call a compiled BASIC program as a subroutine from a noncompiled BASIC program.—Steve

CHAMELEON PLUS POWER SUPPLY

Dear Steve,

In his review of the Chameleon Plus (June 1984, page 327), Rich Krajewski stated that the Chameleon has a switching power supply and that it could be switched only by a dealer. Is there any way to switch it myself?

Also, do the Chameleon Plus, Compaq, and the Panasonic Sr. Partner run Microsoft's Flight Simulator?

DAVID TAY
McLean, VA

When you speak of "switching" the power supply in the Chameleon Plus, I assume you are referring to the review article's mention of being able to switch between 110 V and 220 V. Although I have not seen the power supply in the Chameleon myself, most power supplies of this type do have a simple switch, appropriately marked, for changing between the two voltages. I am assuming that this switch is located within the power-supply box in the Chameleon. If you are the experimenting type, you can remove the power supply from the Chameleon, take the cover off of the supply, and look for a switch marked something like "110–120 V, 50–60 cycle" on one side and "220–240 V, 50–60 cycle" on the other. If you do not find such a switch, do take it to your dealer.

I have personally tested Flight Simulator on the Chameleon and it does not work. Published reports state that it does work on both the Compaq and the Sr. Partner.—Steve

ATARI NUMBER CRUNCHING

Dear Steve,

I have been doing a certain amount of scientific computing on the 6502-based Atari 400 and 800XL computers. The main advantage of these machines is that interactive graphics is easy and nice, but there is a problem with speed as the BASIC and the floating-point hardware are pretty slow. Accessing the floating-point routines with machine language seems to speed things up by only about 40 percent,

(continued)

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at most, and is clumsy.

Is it possible to speed things up by replacing the 6502 chip with the new 65816 in the Ataris, or would something much more extensive be necessary?

Also, I remember seeing an ad for the Fastchip, a faster replacement for the floating-point hardware chip for the Atari. That was a year or so ago. Are they still available, and do you know where I might get a couple?

JOHN COCKE
Tucson, AZ

Replacing your 6502 with a faster chip is possible, but several hardware and firmware changes are required that make it uneconomical.

A less expensive approach is to use the Fastchip. This chip will speed up applications involving floating-point calculations by as much as four times, according to the manufacturer. A review of the Fastchip appeared in the September 1982 issue of Compute! *magazine. The Fastchip is available from Newell Industries, 3340 Nottingham Lane, Plano, TX 75074.* —Steve ■

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, at the end of Ask BYTE I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.

If you would like to share the knowledge you have on microcomputer hardware with other BYTE readers, joining the Circuit Cellar/Ask BYTE staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.

If you're interested, let us hear from you. Send a short letter describing your areas of interest and qualifications to Steve Ciarcia, POB 582, Glastonbury, CT 06033.

IN ASK BYTE, Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to

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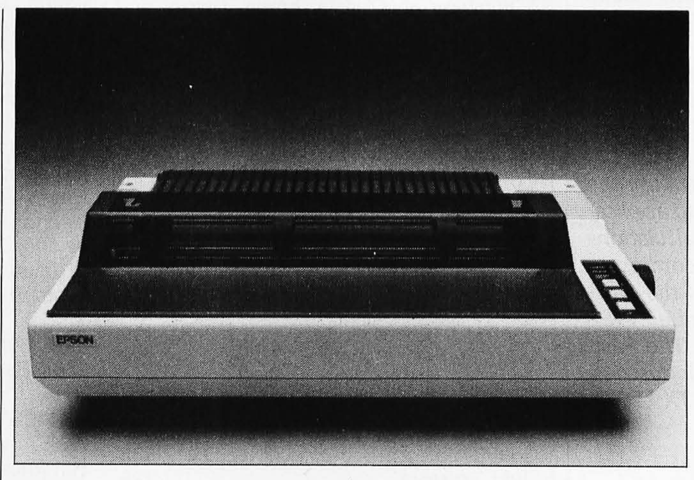
Due to the high volume of inquiries, personal replies cannot be given. All letters and photographs become the property of Steve Ciarcia and cannot be returned. Be sure to include "Ask BYTE" in the address.

The Ask BYTE staff includes manager Harv Weiner and researchers Bill Curlew, Larry Bregoli, Dick Sawyer, Robert Stek, and Jeannette Dojan.

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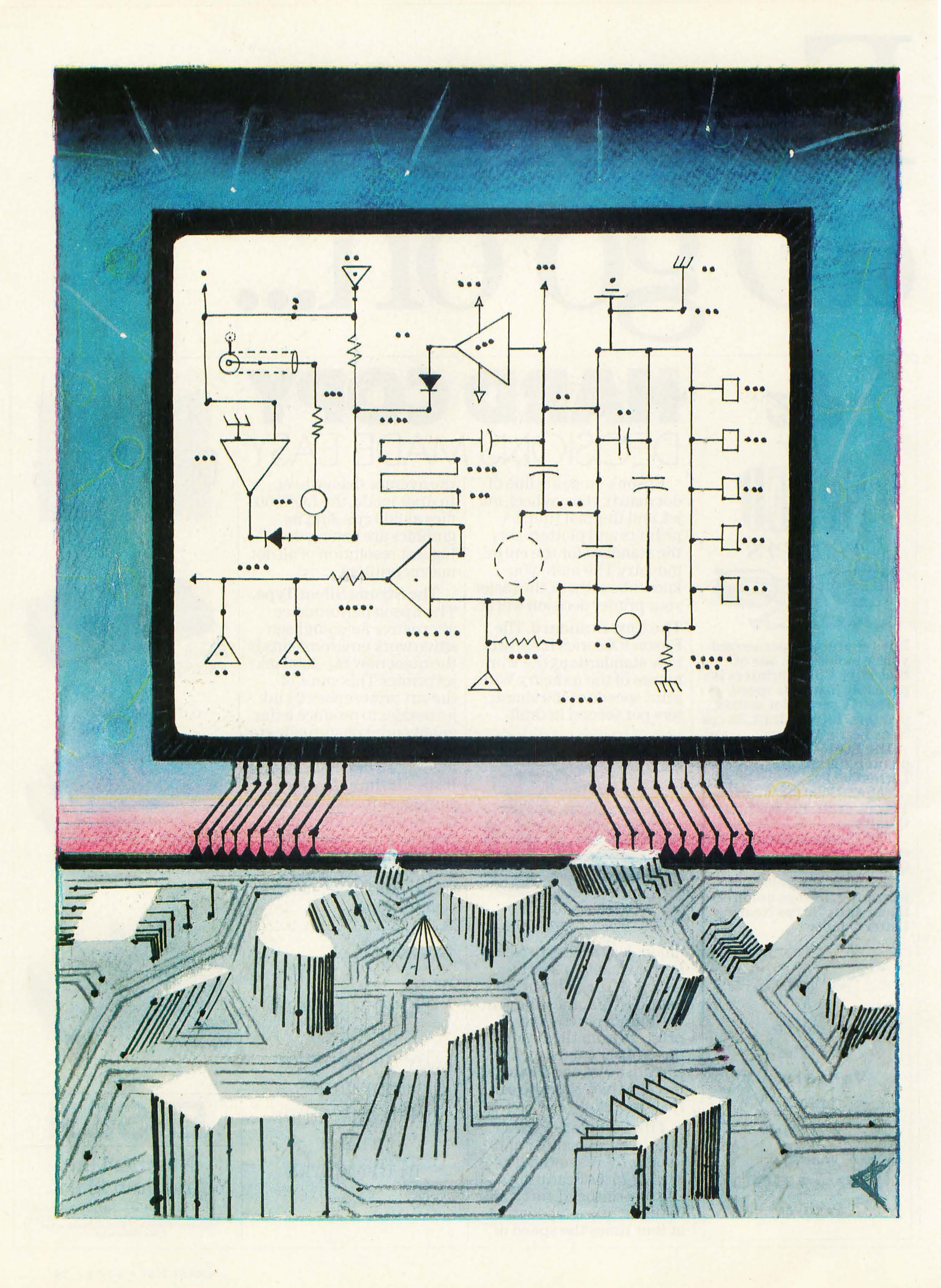
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Features

IN EARLY 1984, officials from a start-up company called Amiga showed journalists prototypes of a new personal computer. The prototypes used a Sage 68000-based machine as a CPU. Big steel boxes performed the special graphics and sound functions that Amiga planned to implement in silicon. The graphics were spectacular—fast enough to support animation. The audio output not only produced music but used stereo to enhance animation. Sound shifted from the right speaker to the left as a ball bounced across the screen. Everyone wondered if Amiga could really reduce all the power in the prototypes to silicon chips.

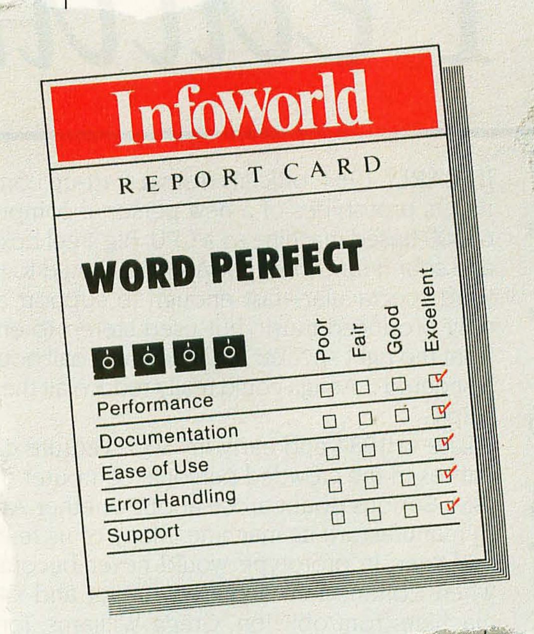
Late in 1984 and early in 1985, venture capital firms became wary of new entries in the crowded personal computer market increasingly dominated by IBM. Serious doubt arose about whether Amiga would be able to get capital to manufacture its machine. Many of us feared that the exciting machine we had seen in prototype would never become a product. We were delighted when Commodore acquired Amiga and saved this technically outstanding machine from oblivion. Gregg Williams, Jon Edwards, and Phillip Robinson give an in-depth look at the technology that makes the Amiga the most advanced and innovative personal computer today.

Steve Ciarcia's Z8 controllers are running all sorts of devices throughout the world. This month, Steve introduces a new controller that is bus-compatible with his Z8 products. The BASIC-52 computer/controller has an 8K BASIC in ROM and so is easy to program. Steve will be developing applications for the BASIC-52 in the months ahead.

BYTE's readers appreciate the 32032 microprocessor from National Semiconductor because of its outstanding architecture and its raw power. Those who want to buy a complete 32032 system can now get systems such as the Elite Computer Systems Expert 32 (see What's New, May, page 464). Those readers who want to move a 32032 into an existing box can complete the DSI-32 32032 coprocessor board for the IBM PC described in this issue. Five authors from Definicon Systems tell about the hardware and software that will give many of us our first taste of 32-bit microcomputing.

The August Programming Project lists Pascal code that can do context-free parsing of arithmetic instructions, which converts them to executable form. The code generates what amounts to a TI-style calculator. In the process of building the calculator in software, you learn a lot about the roots of the parser in linguistic theory of context-free grammars. Jonathan Amsterdam wrote the parser in highly portable Pascal code.

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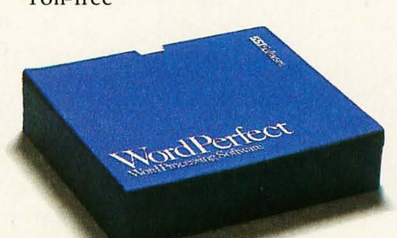
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The AMIGA PERSONAL COMPUTER

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Editor's note: The following is a BYTE *product preview. It is* not *a review. We provide an advanced look at this new product because we feel it is significant. A complete review will follow in a subsequent issue.*

THERE ARE TWO ways to get work done inside a computer: do it in software or do it in hardware. The first way gives you unlimited flexibility; the other, speed. The Apple Macintosh does almost everything in software—and,

(continued)

Photo 1: *The Amiga Personal Computer. The graphics on the display are in the 320-by 200-pixel 32-color mode.*

PHOTOGRAPHED BY MICHAEL CARR

BY GREGG WILLIAMS, JON EDWARDS, AND PHILLIP ROBINSON

IN BRIEF

Name
Amiga Personal Computer

Manufacturer
Commodore International
1200 Wilson Dr.
West Chester, PA 19380
(215) 431-9100

Price
$1295

Microprocessor
Motorola 68000, a 32-/16-bit microprocessor (32-bit internal data path and registers, 16-bit external data bus) running at 7.15909 MHz

Main Memory
256K bytes dynamic RAM, user-expandable to 512K bytes; machine's design allows for maximum of 8.5 megabytes

ROM
192K bytes of ROM containing multitasking, graphics, sound, and animation support routines

Graphics
Five modes (320 by 200 pixels, 32 colors; 320 by 400, 32 colors; 640 by 200, 16 colors; 640 by 400, 16 colors; sample-and-hold mode); independent horizontal and vertical scrolling of dual playfields; eight hardware sprites; colors chosen from a palette of 4096 colors

Sound
Four independent audio channels; sound produced without supervision of 68000

Floppy Disk
Built-in 3½-inch double-sided disk drive. Disks hold 880K bytes in 160 tracks, each with eleven 512-byte sectors; drive hardware can read an entire track at a time

Keyboard
Detached 89-key keyboard with calculator pad, function and cursor keys; keyboard returns row/column keycodes for each key, sends both key-up and key-down signals; can sense up to two keys simultaneously; 8-key type-ahead buffer

Expansion Ports
Disk port onto which three additional disk drives can connect via daisy chain; serial port with maximum transfer rate of 500,000 bps; programmable parallel port normally configured as Centronics-compatible; expansion bus includes full set of signals for optional peripherals and memory expansion

User Interface (Intuition)
Supports multitasking through the use of virtual terminals; allows simultaneous display of different resolutions and graphics modes

Bundled Software
AmigaDOS
Voice Synthesis Library
ABasiC
Tutorial (Mindscape)
Kaleidoscope (Electronic Arts)

Audio and Video Ports
Two stereo audio jacks; RGB analog, RGB digital, and NTSC composite output

Miscellaneous
Three custom chips to control graphics, audio, and peripheral I/O; chips connected by 19-bit register-address bus; two-button mechanical mouse

Optional Peripherals
3½-inch 880K-byte disk drive; RGB analog color monitor; 256K-byte memory expansion module; 300/1200-bps modem; MIDI interface; frame grabber

not coincidentally, people want Apple to increase the Mac's speed, add color, and lower its price.

Commodore has just introduced a computer that promises these improvements, and it does so by doing many things in hardware. At $1295, the Amiga Personal Computer (see photo 1) promises lightning-fast desktop-metaphor graphics in color and twice as much memory and disk storage as the Macintosh for several hundred dollars less than the Macintosh (about $900, but you'll have to buy a monitor or television set for the Amiga). It also has an expansion bus and a whopping 192K bytes of sophisticated 68000 code in ROM (read-only memory) that extends the multitasking, graphics, sound, and animation capabilities of the Amiga hardware.

SYSTEM DESCRIPTION

The Amiga is summarized in the In Brief section on this page. It has no slots for expansion cards, but Commodore later intends to offer a box that connects to the expansion connector to add several expansion slots. (It is theoretically possible to add 8 megabytes of memory in this way.) The Amiga's disk operating system will also be able to look at the expansion box, determine what peripherals are present, and configure itself accordingly, regardless of the box's contents.

SYSTEM ARCHITECTURE

The Amiga has a unique architecture that is only partially described by a functional block diagram (see figure 1). Three custom chips relieve the 68000 processor of many tasks that tie it down in other computers. However, the diagram does not show the finely tuned sharing of the system's data and address buses, the 25 DMA

Gregg Williams is a senior technical editor at BYTE, *and Jon Edwards is a technical editor. They can be reached at* BYTE, POB 372, Hancock, NH 03449. *Phillip Robinson is a West Coast senior technical editor at* BYTE. *He can be reached at* BYTE Magazine, 425 Battery St., San Francisco, CA 94111.

(direct memory access) channels that do many data-movement-intensive operations without tying up the 68000, or the multiprocessing routines in ROM that allow the Amiga to orchestrate a variety of tasks. In the following sections we will look at the key elements of the Amiga's system architecture.

THE CUSTOM CHIPS

The three custom chips that control DMA, graphics, sound, and I/O (input/output) (see photo 2) were designed by Jay Miner, who is best known for his design of the custom chips in the Atari 800 series computers. Although we will discuss them in depth by function, here is a simple breakdown:

- The "animation custom chip" actually contains several miscellaneous functions. It is the "traffic cop" that controls DMA. It contains the Copper, a coprocessor that can directly control the other chips in relation to the video beam, and the Blitter, a device that quickly draws lines, fills areas with a given color, and manipulates rectangular blocks of pixels.
- The graphics custom chip, which manipulates the visible display, permits up to two independent bit-mapped images and eight sprites (which are images that can be moved easily around the screen, "under" or "on top of" the bit-mapped images).
- The peripherals/sound custom chip contains four channels of sound, the disk controller, an interrupt controller, and the interfaces for the serial port and the mouse/joystick port.

INTERRUPTS AND DMA

In the Amiga, all the peripherals are interrupt-driven—that is, the 68000 is not tied up constantly *polling* them to see if they have new data; instead, the 68000 gets data from the peripheral only when the peripheral sends an interrupt signal. The peripherals/sound chip receives interrupt-request signals from one of 15 sources (e.g., the disk drive or a sound channel), translates the request to one of six interrupt levels supported by the 68000 (the seventh is reserved for future use), and sends the interrupt signal to the 68000.

The 68000 shares the address and data buses with 25 channels of DMA, the registers and logic of which reside in the custom chips. Amiga's DMA is fast for two reasons: first, the fact that each device has its own DMA channel decreases the overhead associated with a DMA operation; second, many DMA operations are interleaved with 68000 bus access in a way that makes the DMA transparent to the 68000 (see below for details).

When DMA occurs between memory- and custom-chip registers, the use of the 19-bit register-address bus (see figure 1) makes the transfer twice as fast. By putting the memory address on the address bus and the register address on the register-address bus, the DMA circuitry causes the data value to move directly from the memory address to the register. This occurs twice as fast as DMA would via the 68000, which would first read the data into itself and then write the result to the register.

LIBRARIES AND DEVICES

System software (much of it in the 192K bytes of ROM) contains *libraries*,

(continued)

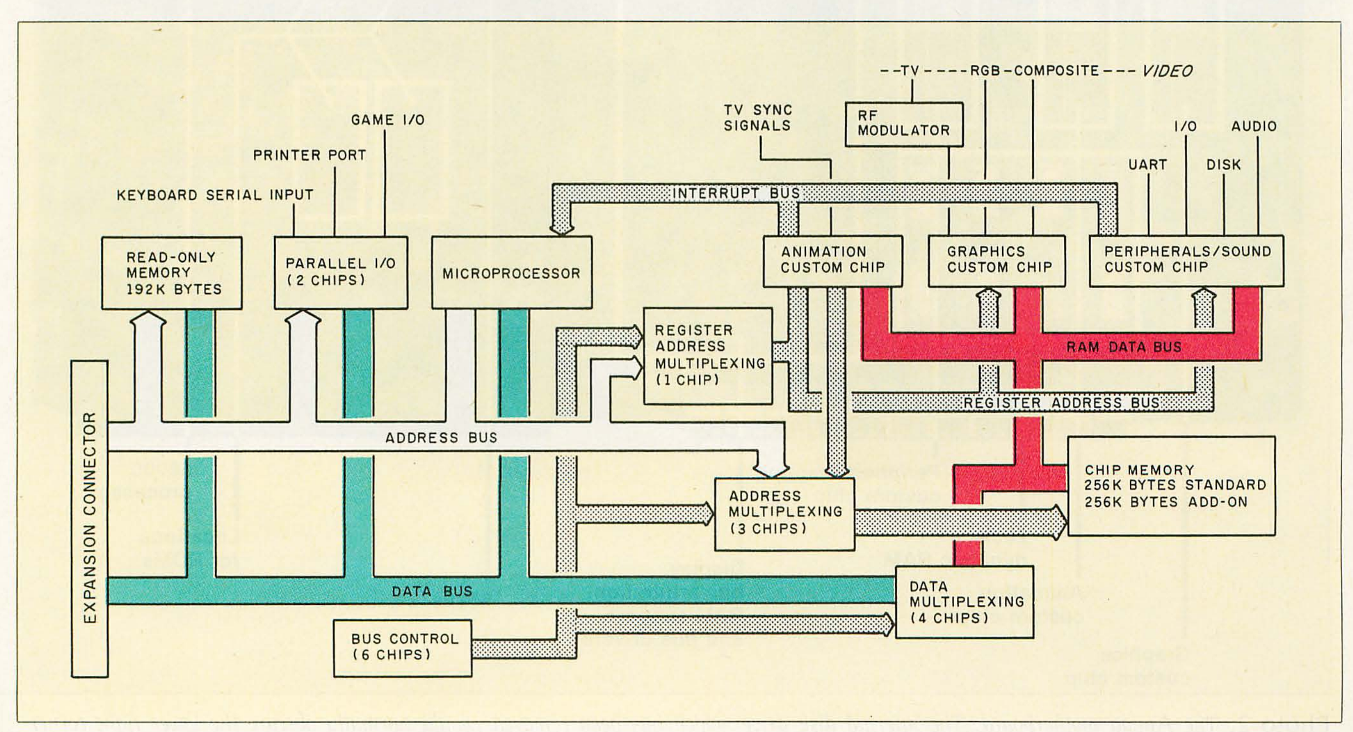


Figure 1: A *block diagram of the Amiga Personal Computer.*

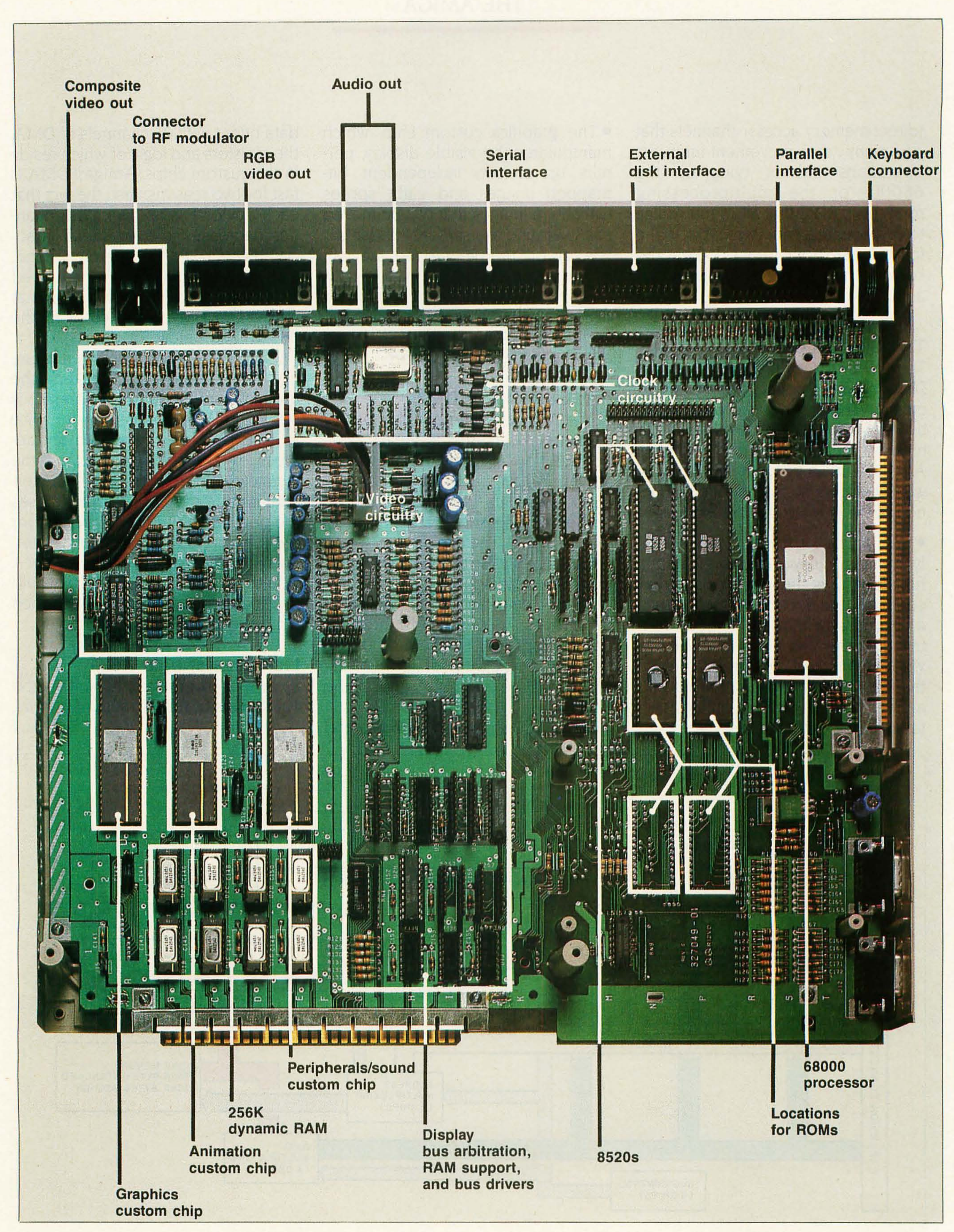


Photo 2: *The Amiga motherboard. The internal disk drive, which has been removed, would normally obscure the lower right corner of the motherboard. The power supply (not shown) is to the left of the motherboard.*

a predefined way of organizing useful routines so that they can be accessed with maximum flexibility. Libraries can be resident or transient and can be used at any memory address (when they're in RAM [random-access read/write memory]). Both routines and data can always be called via a 68000 indirect reference with offset; this allows you to write code using a library routine without knowing that library's address at compile time. (In fact, all the code in the system can be referenced knowing only one fixed address in the machine, and even that address is supplied to any machine that needs it.) A *device* is an extension of the library concept that allows software to access I/O devices (both present and future) in a uniform way.

THE EXEC ROUTINES

The Exec system is a collection of reentrant optimized 68000 ROM routines that perform many functions vital to the operation of the Amiga. It includes routines that create and manipulate lists and queues, schedule tasks by priority, handle interrupts, organize device I/O, control memory use, and perform other functions.

An important data structure in the Amiga is the *list node*. The list node is a block of data with pointers to the predecessor and successor nodes in the list it's in, two 8-bit type and priority fields, and an associated block of data. A *list* is a doubly linked chain of list nodes and items, started by a header that points to the first and last nodes. Exec contains several routines that let you do things like create a new list, insert a list item into its proper place in a queue, and remove a node from a list.

Another important set of routines allows you to manipulate *tasks*. A task is a unit of work that shares the Amiga with other tasks in a way that varies with both the type and priority of the task. (All the current tasks are held in a queue and are executed by decreasing priority.) Most programs and operations reside in the Amiga as tasks.

The task priority field, which contains a number between −128 and 127, determines the order in which

The Exec routines perform many functions vital to the operation of the Amiga.

tasks will execute. Tasks with identical numbers share the Amiga in time slices of preselected duration. A task with higher priority preempts the current task and begins executing. Because the system saves a task's states, registers, and stack area, a task can resume at any time. More important, programmers do not have to make allowances for other tasks that may be running concurrently—while a task is active, it "thinks" that it has full unrestricted access to the 68000.

SHARING THE SYSTEM BUS

Consider that the Amiga can simultaneously read the disk, play four channels of audio, and show 16-color low-resolution bit-plane graphics and eight sprites with virtually no slowdown of the 68000 processor. This is possible largely because of the way various subsystems share the bus.

The Amiga's 68000 runs at 7.15909 MHz, while its memory runs at twice that speed. Most of the instructions in the 68000 alternate between using the bus and doing internal calculation. In this situation, the memory can run at its top speed and still leave every other bus cycle free.

The bus sharing takes place in subdivisions of the time the electron gun takes to draw one line of pixels and do a horizontal retrace, approximately 63 microseconds (μs). This divides into approximately 226 memory-access cycles of 280 nanoseconds (ns) each. The Copper, Blitter, and 68000 access memory on the even cycles (0, 2, 4, . . .); the odd cycles (1, 3, 5, . . .) are reserved for four cycles of memory-refresh DMA, three cycles of disk DMA, four cycles of audio DMA (enough for four channels), 16 cycles of sprite DMA (enough for eight sprites), and 80 cycles of bit-plane DMA (enough to show a 16-color low-resolution image). The DMA circuits on each chip "know" when their slots occur on each horizontal line and automatically initiate the DMA transfer without involving the 68000.

In many cases, the Copper and the Blitter aren't active, leaving the 68000 running at full speed. (Actually, some instructions need the bus at odd times; if the bus isn't available, the 68000 will insert wait states until the bus-arbitration PAL [programmed-array logic chip] signals that the bus is free by asserting the 68000's $\overline{\text{DTACK}}$ line. This happens more frequently as the custom chips demand more of the bus's cycles.)

Several things modify this bus sharing. If you use more than four bit planes of low-resolution display, or more than two high-resolution bit planes, the bit-plane DMA will steal some memory cycles from the 68000. Both the Copper and the Blitter have higher priority than the 68000 and will get the cycles they need first. If the Blitter senses a memory-bus request by the 68000, it will halt within a few cycles to let the 68000 use the bus; then it will again take over the bus and continue. This gives the 68000 some cycles even when the Blitter is running. If you set an internal "Blitter priority" bit, however, the Blitter steals *all* the cycles it needs from the 68000. Even this is not as bad as it sounds; whenever any of the above items steals cycles, it still performs its function faster and more efficiently than the 68000 could have.

MULTITASKING

The Amiga is multitasking—that is, it can work on more than one thing at a time. At a low level, for example, this means that the Amiga can move sprites, read from the disk, and play music at the same time. At higher levels, several programs can run simultaneously in overlapping windows.

The Amiga's multitasking ability comes from several features we've already discussed: the interrupt structure and the Exec multitasking routines in ROM. Interrupts, which are

(continued)

routed through and prioritized by the peripherals/sound chip, initiate task switching. For example, when a peripheral signals its need to do I/O, the interrupt goes through the peripherals/sound chip and causes the peripheral's interrupt routine to execute (assuming that no interrupt of higher priority is running). The interrupt routine either handles the peripheral's need immediately or notifies a task to do so, then the routine ends. In both cases, the Amiga then calls the task rescheduler, which ensures that the appropriate task has the chance to use the system.

THE COPPER

The Copper is a coprocessor inside the animation chip that runs its own program. The execution of this program is tied to the progress of the electron beam as it draws the video display. Because of this capability, the Copper is most often used to control the graphics and sound parts of the custom chips, thus relieving the 68000 of the same task. The Copper reads its instructions from memory and uses DMA to write from its program (in memory) to the registers in itself and the other two custom chips. (According to Jay Miner, this is not so strange if you look at the three chips as "one big custom chip.")

The Copper's instruction set has only three instruction types: *move* immediate data to a register, *wait* until the electron beam passes a given position, and *skip* past the next instruction if the electron beam is past a given location. The beam-position values are accurate to the exact line vertically and to 4 low-resolution pixels (or 8 high-resolution pixels) horizontally.

The Copper's versatility can be extended by clever use of its registers. For example, you can get the Copper to jump to a given instruction by causing the new address to be placed in the Copper's internal "program counter." By setting bit 15 of the INTREQ (interrupt request) register, the Copper can cause a level-6 interrupt, which should lead to a more complex 68000 routine that will service the situation that caused the interrupt.

One important aspect of the Copper is that, while it is waiting for the electron beam, it is off the system bus and does not tie up any resources. This is in contrast to many systems that tie up their processors while waiting for a given beam position. Because of the Copper, the 68000 is never tied up for several milliseconds waiting for a display-related event.

The Copper can handle many basic system functions without the intervention of the 68000. For example, it can refresh certain bit-plane and sprite values that must be restored at the beginning of each frame. It can also change the color palette in midscreen (giving you more than 32 colors on the screen), change the graphics mode (saving memory), and update the display memory without glitches by changing an image *after* the electron beam has drawn it for the current frame.

The Copper programs give the maximum amount of control over the video display and events of that

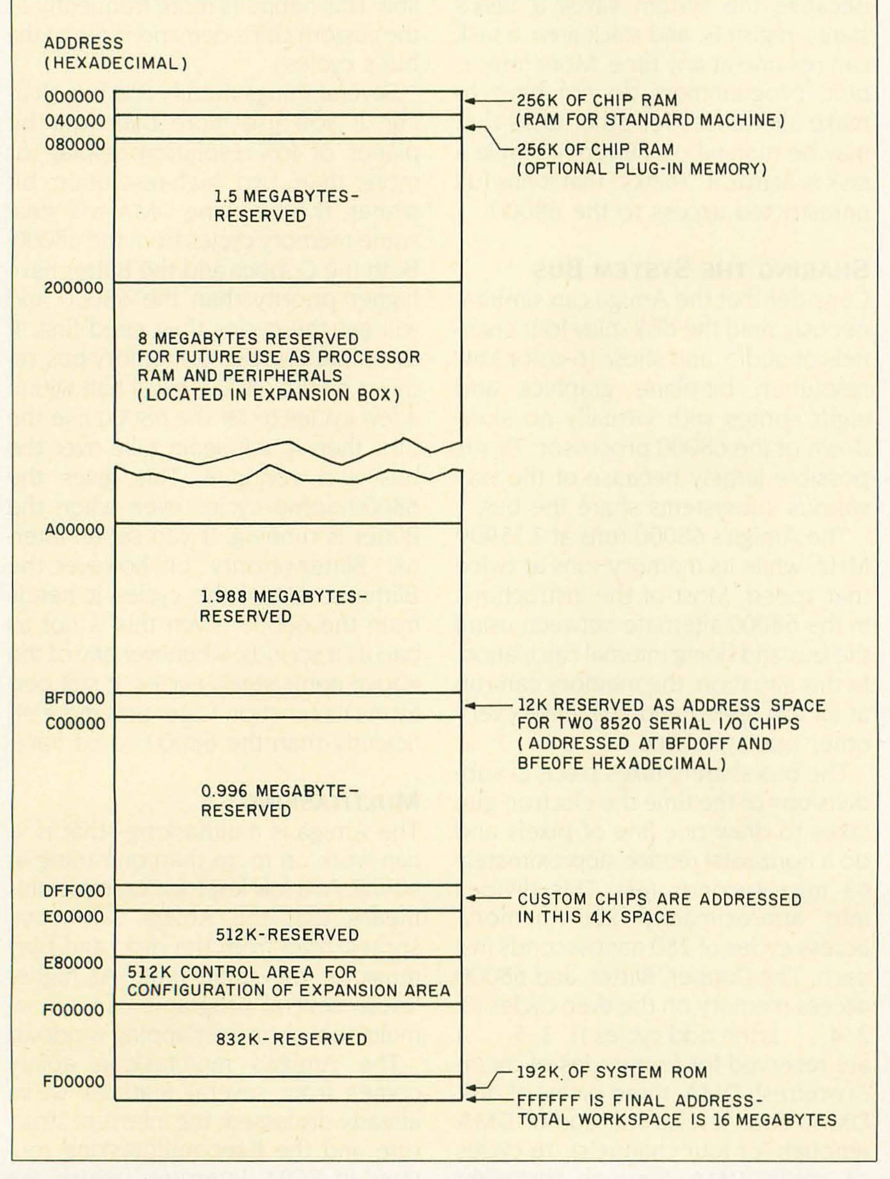


Figure 2: *The Amiga memory map.*

periodicity, but most programmers will not create them directly. Many of the ROM routines that accomplish high-level tasks manipulate Copper programs to get their work done.

MEMORY SPACE

The first 512K bytes of memory is called the *chip memory* (see figure 2 for a memory map). Any function performed by the custom chips—bit-plane and sprite images, Copper programs, and other data (covered below)—must be in this memory area.

Of course, in the standard 256K-byte Amiga (or the expanded 512K-byte version), the chip memory is also used for everything else a computer needs RAM for. Commodore/Amiga may announce an expansion box at a later date that can accommodate various peripheral cards and up to 8 continuous megabytes of memory. Normal programs and data should be placed there, leaving the display memory free for its specialized uses.

GRAPHICS

The Amiga's graphics are, in a word, breathtaking—in both their quality and their speed. The machine's major graphic components are the playfield, the sprites, the Blitter, and the animation and text routines.

THE PLAYFIELD

A *bit map* is an area of memory that the computer interprets as a rectangular array of pixels (dots); most computers have some bit-mapped graphics capability. Many machines form different colored pixels by grouping two or more adjacent bits in the bit map. The Amiga, however, uses only one bit per pixel in its bit map (this is called a *bit plane*) and "stacks" separate bit planes together to get different colors (see figure 3). (The colors available are not "hard-wired" into the machine but are specified in a *color-register table*, also known as a *color palette*.) An image created by multiple bit planes is called a *raster*. The *playfield* is the bit-mapped graphics display that comprises most of the Amiga's video display.

The Amiga can stack up to five bit planes to get a maximum of 32 colors. The color-register table contains 12-bit values that can specify any of 4096 different colors. Therefore, the Amiga can draw images that use any 32 of these 4096 colors.

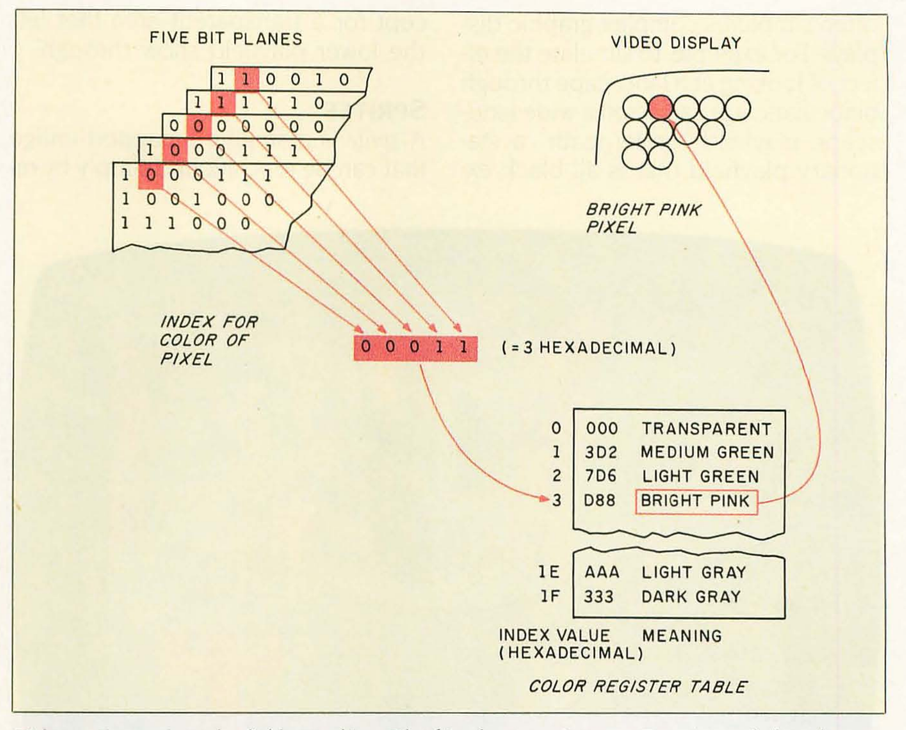


Figure 3: *Amiga playfield graphics. The bits from a given position in each bit plane combine to create an index into the color-register table. The selected entry in the color-register table determines the color of the pixel.*

The Amiga has five bit-mapped resolutions. Four of them come from two horizontal resolutions (320 pixels per line, low resolution, and 640 pixels per line, high resolution) times two vertical resolutions (200 visible lines per screen, *noninterlaced* frame, displayed every 1/60 second, and 400 visible lines per screen, *interlaced* frame, displayed in two passes every 1/30 second). These can take anywhere from a minimum of 4000 bytes (for a 320- by 200-pixel image) to 32,000 bytes (for a 640- by 400-pixel image). Photo 3 shows an example of the 320 by 200 mode.

The fifth mode, called *hold-and-modify*, uses six bit planes in a way that can simultaneously display all 4096 colors on screen. In this mode, the top 2 bits of a pixel control the interpretation of the bottom 4 bits, which may represent either a color-register table value for that pixel or a modification to one component of the previous pixel's color. Using hold-and-modify, you can display all 4096 colors on an analog RGB (red-green-blue) color monitor.

A playfield image can be much larger, both horizontally and vertically, than the screen area used to display it. By manipulating several register values, you can scroll an image horizontally, vertically, or both, with very little effort. (When the total image is wider than its displayed part, the last pixel on one line and the first pixel on the next are not adjacent and are separated by a fixed number of bytes. The Amiga makes use of *modulo registers* to make the manipulation of two such bytes as fast and as simple as if they were contiguous.)

Another display option is called the *dual-playfield mode*. When you use this mode, up to six bit planes are divided into two separate images of up to three bit planes each, with one image having priority over the other. This

(continued)

often simplifies complex graphic displays. For example, to simulate the effect of looking at a landscape through binoculars, you can scroll a wide landscape playfield "underneath" a stationary playfield that is all black except for a transparent area that lets the lower playfield show through.

SPRITES

A *sprite* is a small bit-mapped image that can be repositioned simply by redefining the horizontal and vertical values for its upper left corner; sprites are independent of the playfield and appear to be over or under each other and the playfield(s) according to a specified priority.

Photo 3: *Robocity, an example of Amiga graphics in the 320- by 200-pixel 32-color mode.*

Photo 4: *The Workbench display. This is an example of the 640 by 200 mode.*

The Amiga has eight hardware sprites, each of which can have three colors (sprites are two bit planes deep, and each 2-bit pixel translates to three colors plus transparency). Amiga sprites are 16 low-resolution pixels wide by any height. Each pair of sprites shares a different three-color color-register table (for example, sprites 0 and 1 share color registers 17, 18, and 19, sprites 2 and 3 share 21, 22, and 23), allowing the eight sprites to use up to 12 colors. Adjacent sprites (0 and 1, for example) can be *attached*, meaning that their four bit planes are combined; an attached sprite pair can then use color registers 17 through 31 to display up to 15 colors.

As happens often in the Amiga, complexity underlies apparent simplicity. A sprite is actually a 16-bit value with a specified horizontal displacement for the current line of the video display. In *manual mode*, you are responsible for creating the sprite's image on a line-by-line basis (few people will use this mode directly). In *automatic mode*, however, you activate the sprite's DMA circuitry, which looks to a data structure that contains the line-by-line position and shape of the sprite and draws it automatically. In addition, you can redefine the sprite indefinitely while the electron beam creates the video display. The sprite DMA circuitry accepts a list of sprite position and shape-definition words and draws them as long as the bottom line of one occurrence and the top line of the next are separated by at least one video line (note that this is *without* intervention of the Copper).

THE BLITTER

The Blitter is an area of the animation chip that controls a DMA channel dedicated to drawing lines and manipulating rectangular areas of the playfield. Its name comes from an earlier

(continued)

The most BASIC.

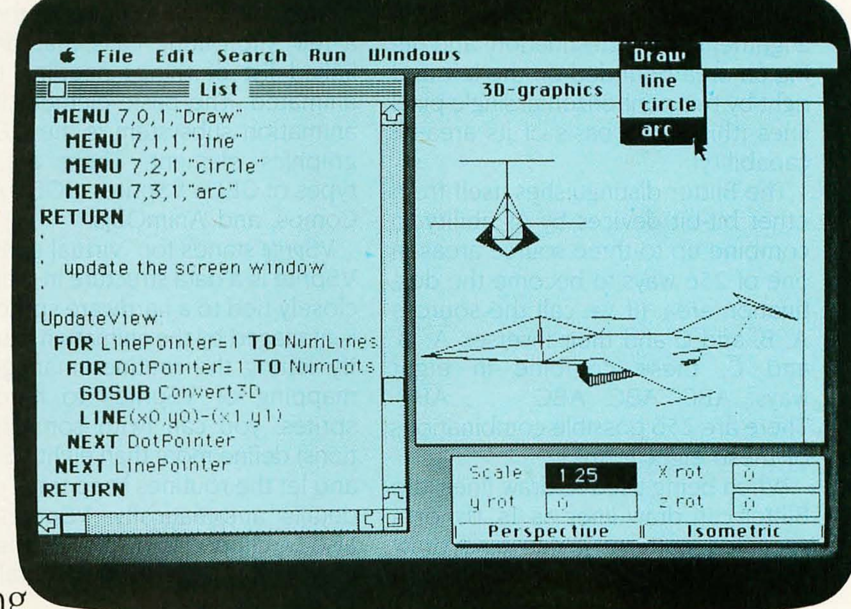
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term, *bit-blt*, which means "bit-mapped block transfer." Miner calls it a B*immer*, for "bit-mapped image manipulator," because of its extended capabilities, but "Blitter" is used exclusively in the Amiga's documentation.

When manipulating blocks of an image, the Blitter (when properly set up) takes care of a number of "housekeeping" tasks that, in other computers, tie up a lot of the processor's time. These include: masking out the bits just outside the image that belong to the same memory word as the desired bits; shifting the image several bits horizontally to match the word alignment of the destination; and filling an area bounded on the left and right by two nonhorizontal single-pixel lines (this is the basis of its area-fill capability).

The Blitter distinguishes itself from other bit-blt devices by its ability to combine up to three source areas in one of 256 ways to become the destination area. (If we call the sources A, B, and C and their inverses $\overline{A}$, $\overline{B}$, and $\overline{C}$, these combine in eight ways: ABC, AB$\overline{C}$, A$\overline{B}$C, . . . , $\overline{A}\overline{B}\overline{C}$. There are 256 possible combinations of these eight terms.)

When being used to draw lines, the Blitter can draw lines as 1s, 0s, or a specified pattern; it can also draw single-bit-wide lines, which are needed to bound an area to be filled.

In both its line-drawing and area-manipulating operations, the Blitter must have a moderate amount of "housekeeping" calculations done first. Given the speed and simplicity of the resulting operation, the setup calculations are not an unreasonable overhead; however, you can deal with the Blitter on a higher level using some graphics routines in ROM.

Animation Routines

The animation routines that are part of the Amiga's ROM form the basis for the most sophisticated color animation the personal computer market has ever seen. One of the demonstrations we saw, Robocity, showed five cartoon characters roaming across the screen. The resolution was very good—only when you looked closely

> *The basic element in the animation subroutine is the GEL, a graphics element.*

could you see the "jaggies" that proved you weren't looking at a hand-drawn cartoon.

Animation is accomplished through a few subroutine calls that draw a linked list of things needing to be animated. The basic element in the animation subsystem is the *GEL*, or graphics element. There are four types of GELs: VSprites, BOBs, AnimComps, and AnimObjs.

V*Sprite* stands for "virtual sprite." A VSprite is a data structure in memory, closely tied to a hardware sprite, that is managed by the animation routines. By letting the routines manage the mapping of VSprites to hardware sprites, you can (with some limitations) define more than eight VSprites and let the routines keep track of the details automatically. VSprites can also be clipped to display themselves only within a certain horizontal slice of the display.

BOB stands for "Blitter object." A BOB is an image that acts like a sprite, but the animation routines use the Blitter to "paste" the image onto the playfield and (optionally) restore the image that was "underneath" the BOB. A BOB is defined by the combination of a BOB data structure and a VSprite data structure, both of which point to each other. One advantage of a BOB over a VSprite is that a BOB is drawn into a playfield—this means it can be of any width and it can have as many colors as the playfield (up to 32). BOBs can also be clipped to appear only in a certain rectangular window.

An A*nimComp* is an animation component, one part of an A*nimObj*, an animation object. If your AnimObj is a figure of a man walking, its AnimComps will probably include BOBs for a torso, a head, two arms, and two legs. Each AnimComp includes several views of the same object (e.g., arm bent, arm straight) with an associated time that must elapse before progressing from one view to the next. Once all this is assembled, repeated calls to the Animate routine substitute new views (as determined by their timer constants) into the linked list of GELs before drawing the items in the list.

You can do *sequenced drawing animation* by specifying a series of views that describe a repeated motion and by specifying an offset to add to the object's position each time the routines cycle from the last view to the first. For example, take the example of a cat walking two steps to the right in six views so that view 1 appears natural when it is shown after view 6. By specifying the correct horizontal offset to the right (which gets added every time the image cycles back to view 1), the Animate routine will automatically draw the six views in the correct order and position to make the cat appear to walk across the entire width of the screen.

Alternatively, you can have the Animate routine do *motion-control animation*, in which the next position of a BOB is automatically calculated from its current position and four *x*- and *y*-axis velocity and acceleration values. (You can also do this with a "ring" of BOB views that cycle as in sequenced drawing animation.)

Another routine, DoCollision, detects two types of collisions, GEL-to-GEL collisions and boundary collisions (collisions of GELs with rectangular boundary windows); the routine then executes a given collision-handling routine from a table of 16 possible routines. GELs can be coded so that only certain types of collisions register (useful in a game, for example, to detect missile-target collisions but not missile-missile collisions).

Text

The Amiga treats text as a special kind of graphics. Fonts are described

(continued)

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by a Text Font (TF) data structure that allows the creation of either monospaced or proportional characters of any height. To save room with larger fonts, a font may define anywhere between 1 and 255 characters. Two fonts, Topaz 8 and Topaz 9, are in the Amiga ROM. The first gives 40 characters per line in normal resolution, 80 in high resolution; the second gives 30 and 60 characters per line, respectively. Additional fonts may be loaded into and removed from RAM as needed.

The Amiga uses the ROM routine TxWrite to draw a given message to a given location. The text can be drawn in one of two user-definable "pen" colors and in one of three drawing modes: JAM1, an overstrike mode; JAM2, a mode that draws both the character in one color and the "white space" behind it in another; and Complement, which inverts every pixel that corresponds to a pixel of the character being drawn.

As in the Apple Macintosh, fonts may be modified by combining any of several styles: underline, italic, boldface, and extended. However, unlike the Macintosh, the Amiga text-drawing routine looks for a separately defined font that contains the needed style(s). If this fails, a future revision of the text-drawing routine may try to modify the existing "normal" version of the font (this is the only way of achieving font styles in the Macintosh).

Fonts may be modified by any combination of several styles: underline, italic, boldface, and extended.

AUDIO HARDWARE

The Amiga includes four hardware channels of sound that are largely controlled by DMA circuitry, independent of the 68000. Audio-controlling routines in part of the Amiga's ROM extend these capabilities, allowing you to work with the Amiga's sound capabilities at a higher conceptual level and to manipulate the sound channels "on the fly" without "glitching" the output.

The four channels of sound, numbered 0 through 3, are converted to analog signals, filtered through a low-pass filter, and mixed into two separate output signals, one combining channels 0 and 3, the other, channels 1 and 2. The filter begins to attenuate frequencies between 5.5 kHz and 7.5 kHz and effectively eliminates any higher frequencies. This eliminates much *aliasing*, which is distortion that occurs when a signal that was sampled too infrequently is played back.

The sound channels can be controlled directly by the 68000, which gives you complete control over the sound but keeps the 68000 from doing other work. In most cases, you can get the sound you need by letting the DMA channels produce the sound from a table of values (called a *sound table*) that describe one or more cycles of the needed waveform.

In the Amiga, each audio DMA channel includes registers that give the channel's loudness, point to a 16-bit-wide table of sound-table bytes (the values are fetched a word at a time and must be stored on even byte boundaries), and establish the time that must elapse before the next sound byte is sent out. This last is a *period register*, which contains a value that is decremented every 279 ns; the next value from the sound table is sent out when the counter reaches zero, and the register is reset to its original value. When the pointer to the sound table reaches its last value, the pointer is reset to the start of the table. In this way, the audio channel continues to produce the given waveform without supervision until it is explicitly turned off.

Sound channels 0 through 2 can be *attached* to the channels directly above them to modulate the output of the higher channel. When a channel is attached, the 16-bit words that make up its sound table are not interpreted as two 8-bit sound values. Instead, the data words are interpreted as volume or period values for the current value in the channel being modulated (i.e., the volume value will determine the current loudness of the channel, and the period value determines how much time passes before the channel sends out the next value in *its* sound table). You can manipulate these values to cause either amplitude modulation, frequency modulation, or both.

AUDIO SOFTWARE

The ROM contains three kinds of routines. The first, channel-allocation routines, allow you to allocate, use, and discard a channel without keeping track of which channel it is. If you have more than four "virtual" channels open, the four with the highest priorities are mapped to actual hardware audio channels.

Second, the DMA-control routines control the way the audio DMA channel manipulates the hardware audio channel via the various registers and the sound table. In addition, you can cause the channel to send a user-specified signal bit to an existing task (which may then trigger some event) when the sound channel has played a given number of repetitions of the sound table; this allows tasks to manipulate the Amiga based on the sound channel's activity.

Third, the envelope-generator routines automate the task of varying the amplitude envelope that determines how slow or fast a note changes volume when it is played. To use these routines, you must create a table of four slope/destination values that describe an ADSR (attack, decay, sustain, release) envelope. (The ADSR envelope tells you how fast the note gains volume as soon as it starts, what its maximum value is, how fast it decays once it reaches that value, on what level it remains as long as the note is sustained, and how fast it returns to zero once the note is released. You can draw such an envelope with four line segments; the

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Amiga defines the ADSR envelope by giving the slope and destination *y*-axis values for each line segment.) As with the audio DMA, the software involved can be told to send a signal bit to a given task when the envelope is completed.

One potentially significant piece of code is a library of text-to-speech routines that is included with the standard Amiga computer. These are transient routines that are loaded from disk to memory when needed; they are capable of "speaking" normal English text in a variety of pitches and rates via one of the sound channels. We heard the routines and found their output to be heavily inflected but understandable even with our eyes closed (a test that many text-to-speech algorithms fail).

INTUITION

Intuition, the user interface of the Amiga, sits on top of the disk operating system and provides the icon-oriented, mouse-based, desktop-metaphor interface popularized by the Apple Macintosh. Intuition complements the architectural philosophy and the graphics capabilities of the computer by managing a complex windowing system and providing access to multitasking capabilities.

Intuition allows programs to execute, each in its own window, simultaneously. Each program opens a *virtual terminal* that has access to all the system resources. Even though multiple programs can execute simultaneously, only one can accept input and display its menu bar. You can select which program does this by clicking on its window; this window will also display special command messages from the system. Different programs can share the video display, or a single program can create several virtual terminals.

To support the simultaneous display of different resolutions and graphics modes, Intuition uses *screens*, which are rectangular areas that occupy the full width of the video diplay. Screens have predefined resolutions, color palettes, and height and contain one or more windows. A bar at the top of each screen identifies the screen.

All screens have pull-down menus. Pressing the right mouse button, which generally summons a menu, transforms the screen bar into a menu bar (a strip containing the names of the menus that apply to the currently active window). The screen bar also contains two boxes that, when clicked with the left mouse button (generally responsible for selecting things), move the screen to the top or bottom of the stack of screens. You can select menu items in the conventional way, although there are several new features. Pull-down menus, for example, can have up to two levels (see photo 4). Menus can contain options that, when selected, persist until other, mutually exclusive choices are made. Programs may allow you to use command-key/letter combinations to select commonly used menu items.

Programmers have considerable flexibility in designing the menus. For example, menus can appear in multicolumn format and contain graphics. Menu items can, when selected, be marked with checks, and they can automatically display command-key/letter alternatives.

Windows, which appear within screens, can support all of the Amiga's graphics, text, and animation features. Since Intuition opens application programs in windows, applications must specify their graphics, text, and color requirements by selecting or creating an appropriate screen. Intuition will support as many screens and windows as can fit in memory, but only one window and, by extension, one screen can receive input at a time. As a virtual terminal, programs need not know if they are active; they can continue to process data as long as they don't need any external input.

You can activate a window either by moving the on-screen pointer inside it and clicking the mouse button or by moving an icon into it. Closing a window causes the last activated window to be reactivated. Windows can include any of several features, including vertical and horizontal scroll bars, title bars, window-dragging areas (used to drag the window to a new position), depth arrangers (which move the window to the top or bottom of a stack of windows), sizing boxes (which allow you to change the window's size), and close boxes (which close a window).

Intuition supports *backdrop windows*, which open behind all other windows and cannot be moved, sized, or depth-arranged. The application program is entirely responsible for maintaining its contents, and normal windows appear on top of it. A graphics program, for example, may use a backdrop window as the primary drawing area and call a normal window to show you a palette of colors from which to choose.

Programmers can specify whether an application will refresh its window when partially covered and uncovered, or whether memory must be allocated to save the concealed portions of the window. A third choice, *super bit map*, reserves enough memory to store an image larger than the windowing system will display. Intuition automatically adjusts and displays as much of the super bit map as it can. Programmers can use this technique to create windows whose contents scroll. They can also determine where windows will appear, what color to use when drawing the border and text, whether the window will have a border, and whether to include a window title.

REQUESTERS, ALERTS, AND GADGETS

Requesters are pop-up information boxes that wait for either keyboard or mouse input from you. Normally, you will have to click the left mouse button over an "OK" area before continuing, although you may be able to switch to a different window (the requester will still be there when you return to the first window). With a single call, programmers can attach requesters to a window or to the double click of the mouse button.

Programmers have access to predefined system requesters, like the "Please Insert Disk XXXX" requester.

(continued)

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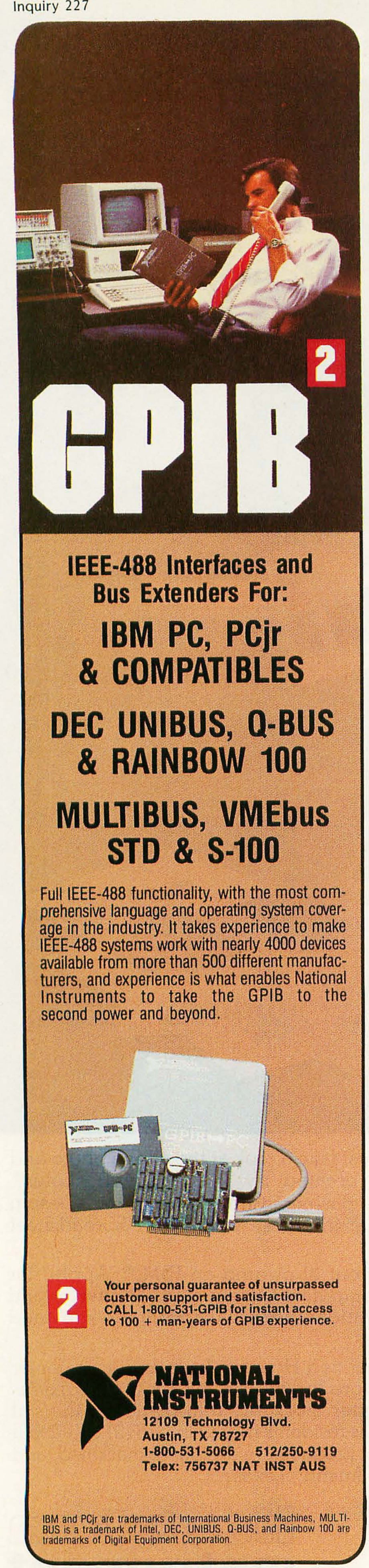
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Inquiry 147

4P019



To use a custom requester, however, the programmer must specify things like gadgets (discussed below), borders, requester text, and, if desired, hand-designed bit-mapped images.

Alerts are special screens that carry absolutely crucial information. They differ from requesters in that no screen or window can obscure them, and users must act immediately on the information before proceeding. *Recovery alerts* require immediate responses; *dead-end alerts* tell users that the system has crashed.

Screens, windows, requesters, and alerts all use *gadgets*, which are input devices that attach to windows, requesters, and alerts. *System gadgets* include window-sizing gadgets, window-/screen-dragging areas, depth arrangers, and close boxes.

Programmers can design their own gadgets by specifying border shapes and colors, describing the select box of the gadget, providing gadget text, supplying a memory buffer for the gadget response, and defining how the gadget will behave.

In addition to system gadgets, programmers can select among Boolean, string, integer, and proportional gadgets. *Boolean gadgets* are true/false devices that return a value only when selected. *String gadgets* return a string from the keyboard. *Integer gadgets* return integer values. *Proportional gadgets*, which return a value proportional to their positions on either the horizontal or vertical axis (or both), are similar to scroll bars on the Macintosh. A programmer can customize the appearance of the *knob* (the element that slides along the axis of movement) to something different from the default rectangular shape.

THE WORKBENCH

Intuition includes Workbench, an iconic, window-based command interface. The Workbench area is a four-color screen with 640- by 200-pixel resolution. It is both a *screen* on which disks will open and application programs will run and an *application* that keeps track of Workbench objects and displays information using Intuition windows. The Workbench automatically opens when you enter a disk containing it. By opening the Workbench library, programmers can access Workbench functions to create and manipulate the Workbench and Workbench objects.

In the Workbench, users can open and close disks, tools, projects, drawers, the clipboard, and the trash can. Opening a *tool* (Amiga's term for an application program) creates a window on the current screen. Tools create *projects*—files associated with the tool. (A document file, for example, is the project of a word-processing application.) Opening a tool automatically opens a window that lists the names of available projects. Opening a project icon automatically opens the tool associated with it.

Workbench also supports *extended selection*, a method of selecting multiple items that will be operated on in the order they were selected. For example, you can select a word processor and three projects (documents); the word processor will then work on the projects in the order in which they were selected.

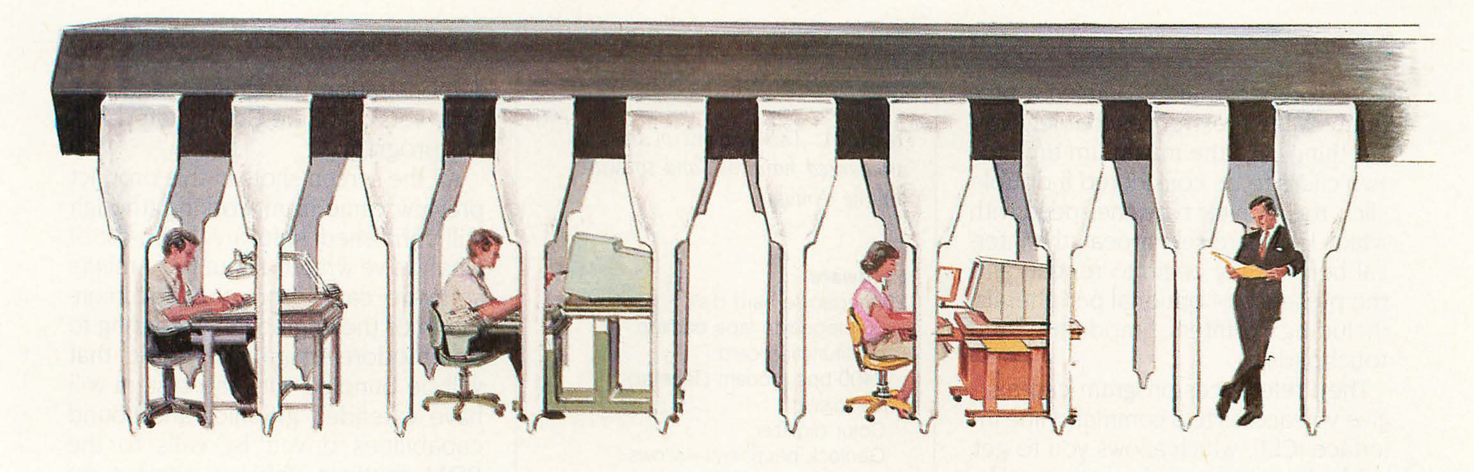
Drawers are Workbench icons that contain tools, projects, and other drawers; when opened, they display their contents as icons in a window. To add an item to the drawer, either drag the item's icon into the window of an opened drawer or drop it over a closed drawer's icon. You can delete an item by moving its icon over the trash can, a special drawer in each disk drawer that contains deleted objects.

The *clipboard* is a special object that lets you transfer data between tools (programs). The clipboard stores the last text, graphics, or data cut from a project as a RAM-based file (disk-based if the clipping is too large for memory). By using the clipboard, you can quickly transfer information between tools or projects.

Programmers can also design custom screens, in which they can specify things like the screen size and position, the number of colors available, the screen titles, and the default font.

(continued)

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XASM48	8048/8041	200.00	250.00
XASM51	8051	200.00	250.00
XASM65	6502/65C02	200.00	250.00
XASM68	6800/01,6301	200.00	250.00
XASM75	NEC 7500	500.00	500.00
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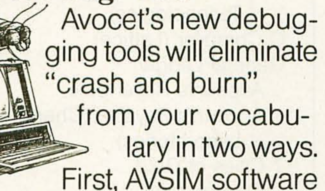
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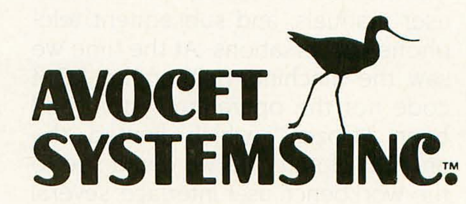
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The Workbench also contains a program called Preferences that lets you set things like the maximum time for two clicks to be considered a double click, the monitor type, the speed with which keyboard keys repeat, the interval before they begin to repeat, and the presence of optional peripherals, including printers, modems, and touchpads.

The Preferences program can also give you access to a command-line interface (CLI), which allows you to get work done via typed-in commands. The CLI, which opens as a window under Workbench, will not be heavily documented in the standard manuals, and you will normally not see the icon associated with it. The CLI uses commands that are similar to those of Microsoft's MS-DOS. It can, for example, examine directories, run programs, and redirect input and output; in essence, it gives programmers access to the operating system that is "underneath" Workbench.

CAVEATS

This product preview is unusual in that we looked at the Amiga in an earlier state than we usually do for other product previews. We feel justified in doing this for two reasons: First, the hardware *was* in its final state (the custom chips were working on the production-version motherboard, although the PROM [programmable read-only memory] chips did not contain the final version of the ROM code); second, the Amiga should be announced by the time you read this, and we feel that the technology used here is noteworthy. BYTE will print a formal review of the Amiga as soon as we can get our hands on a finished machine.

We wrote this product preview after two days with the Amiga engineering staff, much study of four volumes of technical documentation and several user manuals, and subsequent telephone conversations. At the time we saw the machine, neither the ROM code nor the operating system had been "frozen," which limited the amount of software we could see to the Workbench user interface, several demonstration programs, and an early version of the Graphicraft drawing program.

All the screen shots in this product preview came from working (though still unfinished) software, but most of what we've written about the Amiga's software came from the documentation or the engineers. According to Commodore/Amiga, the BASIC that will be bundled with the system will have extended graphics and sound capabilities driven by calls to the ROM routines. Table 1 gives a list of products for the Amiga that we learned of from their respective manufacturers.

Table 1: *This is a list of the announced hardware and software for the Amiga.*

Hardware

20-megabyte hard disk,
20-megabyte tape backup,
multifunction card,
2400-bps modem (Tecmar)
Laser disk,
Color digitizer,
Genlock peripheral—allows computer's display to overlay an external video signal (Commodore)

Software

Pascal,
Linkage Editor,
Overlay Loader,
Macro Assembler (Metacomco)
Turbo Pascal (Borland International)
Logo (The LISP Company)
Propaint,
Business Graphics,
Graphicraft,
Animation (Island Graphics)
Enable/Write (The Software Group)
Textcraft (Arktronics)
Musicraft (Commodore)
Harmony and four-octave music keyboard,
Pitchrider (Cherry Lane Technologies)
C Compiler (Lattice)
General Ledger,
Accounts Receivable,
Accounts Payable (Chang Laboratories)
7 Cities of Gold,
One on One,
Archon,
Adventure Construction Set,
Pinball Construction Set,
Skyfox,
Financial Cookbook,
Deluxe Music Construction Set,
Black Knight,
Video Construction Set,
Return to Atlantis (Electronic Arts)
Communications package (Software 66)
Welcome Aboard,
Print Shop,
SynCalc,
Mindwheel (Broderbund)
Keyboard Cadet,
The Halley Project (Mindscape)
All Infocom Interactive fiction products

CONCLUSIONS

We were impressed by the Amiga's detail and speed of the color graphics and by the quality of its sound system. The interlocking features of the Amiga—its custom chips, multitasking support, multiple DMA channels, shared system bus, display-driven coprocessor, system routines in ROM, etc.—point to a complexity of hardware design that we have not seen before in personal computers. (It's interesting to note that the Macintosh's complexity is in its software and that, according to several third-party developers who have used both computers, the Macintosh is harder to program.) The synergistic effect of these features accounts for the speed, quality, and low cost of the Amiga.

We are also very excited about the inclusion of the text-to-speech library in the Amiga. This means that *any* Amiga program can potentially create voice output, something that has never been common in personal computers because it was never, until now, a standard feature.

The hardware looks good—we have seen it work—but we saw very little software actually working (a painting program, the Workbench "desktop," and a few demonstration programs). However, we think this machine will be a great success; if that happens, the Amiga will probably have a great effect on other personal computer companies and the industry in general. ■

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Examples of software which show dramatic speed-ups include AUTOCAD, 1-2-3™ worksheets which depend heavily on financial or transcendental functions, and multi-user operating systems. Any program written with an MS-DOS compiler that supports the 8087, such as MS-FORTRAN or 87BASIC, will run on the NUMBER SMASHER at least a factor of 2.5 times faster! Software that comes with the card also increases the throughput of I/O bound programs and includes a disk cache routine, ram disk and print spooler.

The NUMBER SMASHER is an upgrade product for 8088 based PCs and compatibles. It works on the IBM-PC and XT, the COMPAQ and compatibles manufactured to the IBM-PC hardware standard. Contact MicroWay or your local MicroWay Installation Center for technical specifications and supporting benchmarks.



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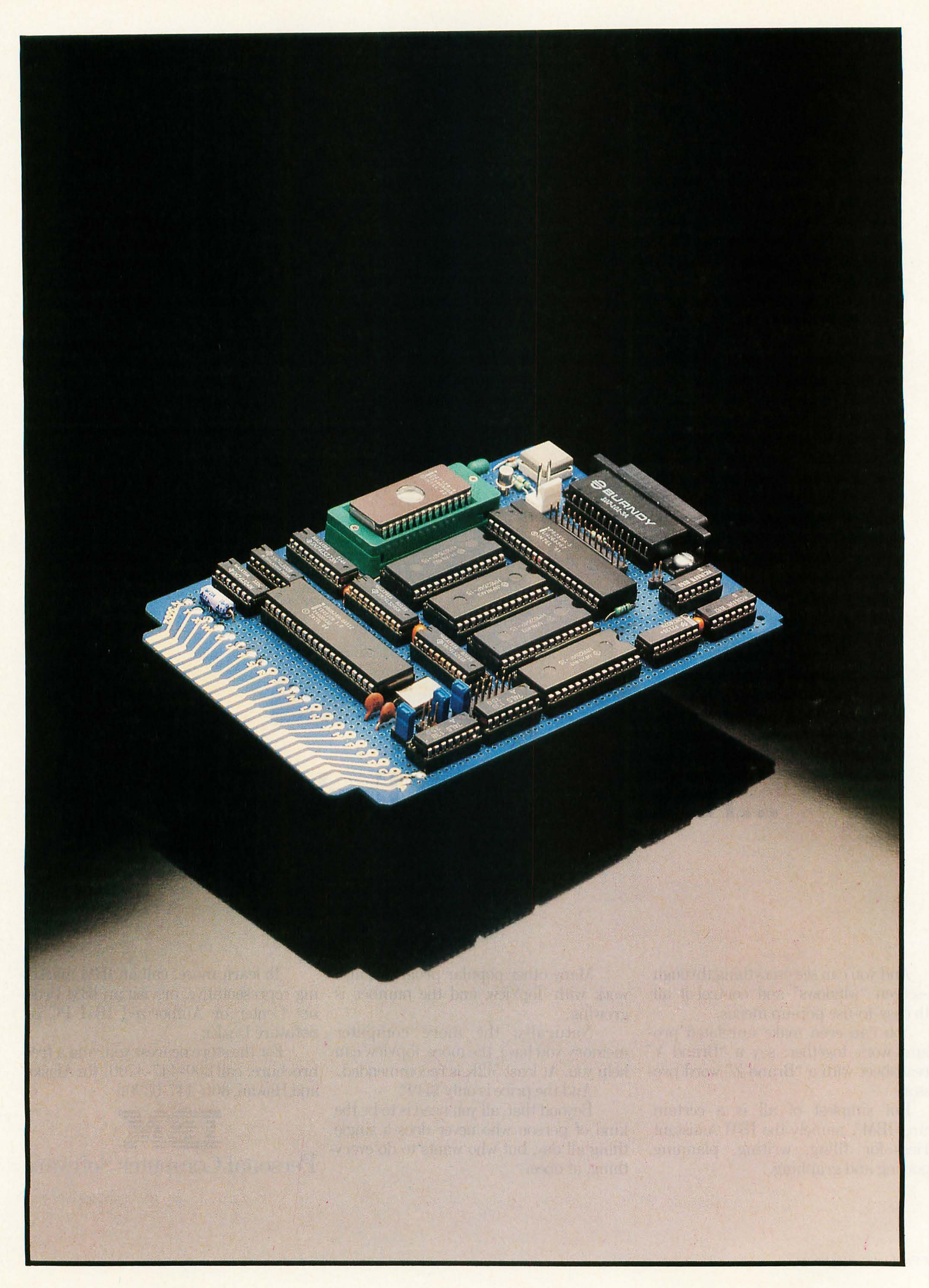
After that, the greatest distance between two programs is just a couple of keystrokes, or (optional) mouse moves.

There's no waiting and a lot less diskette swapping.

But when you're *really* busy is when TopView really shines, letting you do many jobs simultaneously.

For example, you can print a letter, while you search a file, while you analyze a spreadsheet, while your clock/calendar reminds you that your automatic dialer is about to place a call for you.

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PHOTOGRAPHED BY PAUL AVIS.

BUILD THE BASIC-52 COMPUTER/ CONTROLLER

BY STEVE CIARCIA

A single-board problem solver with great potential

One of the most popular Circuit Cellar projects was the Z8 BASIC computer/controller presented in July and August of 1981. Since then, thousands of Z8 controller boards have found their way into end-user and OEM applications.

I specifically designed the original Z8 controller because I hate programming. Generally speaking, if the program has fewer than 100 lines I'll grin and bear it. Any longer than that, however, and I lose interest and call in a programmer. To ease the pain, I generally use high-level languages like BASIC. Most people understand BASIC, and it excuses me from wasting time on tedious bit manipulations merely to demonstrate a hardware peripheral device. (My favorite programming language is solder.)

I don't try to justify using BASIC, I just get results. While others are arguing the merits of Pascal and C, I've plugged in my single-board computer/controller and am plinking away in BASIC to solve the problem. I've learned enough about other programming languages so that I know when to nod appreciatively at a programmer's description of a random-number seed generator written in some obscure programming dialect.

This "plug and program" approach has been adequately satisfied by the Z8, but I find that I purposely avoid applications involving floating-point calculations or trigonometric functions that would otherwise force me to resort to assembly-language programming (ugh!). In an effort to forestall my inevitable defection from BASIC, I am continually on the lookout for cost-effective performance boosters that I can package as single-board problem solvers (that execute in BASIC, naturally). And I just found another one!

What I have found is the Circuit Cellar BASIC-52 computer/controller (BCC-52) board. It uses the new Intel 8052AH-BASIC microcontroller chip that contains a ROM (read-only memory)-resident 8K-byte BASIC interpreter. The BCC-52 board includes the 8052AH, 48K bytes of RAM/EPROM (random-access read/write memory/erasable programmable ROM), a 2764/128 EPROM programmer, three parallel ports, a serial terminal port with automatic data-transmission-rate selection, a serial printer port, and is bus-compatible with the BCC-11 Z8 system/controller and all the BCC-series expansion boards I've already designed. Figure 1

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

is a block diagram of the hardware.

BASIC-52 is particularly suited for process control, providing IF... THEN, FOR...NEXT, DO... WHILE/UNTIL, ONTIME, and CALL statements among its broad repertoire of instructions (figure 2 lists the software features). Calculations are handled in integer or floating-point math and are fully supported with trigonometric and logical operators. Because of its low system overhead it is extremely fast and efficient.

I'll get into the system configuration and the design details momentarily, but I first have to mention an interesting aspect of BASIC-52. While I considered using EEPROMS (electrically erasable programmable ROMs) and other nonvolatile storage techniques, the sophisticated EPROM programming capabilities of BASIC-52 justified eliminating them simply on the basis of cost and board real estate. Unlike most one-shot EPROM programmers that fill the entire contents of an EPROM regardless of the application program's size, BASIC-52 treats the EPROM as write-once mass storage.

When a BASIC application program is saved to EPROM, it is tagged with an identifying ROM number and stored only in the amount of EPROM required to fit the program (plus header and EOF [end of file]). Additional application programs can be stored to the same EPROM and recalled for execution by requesting a particular ROM number. A 27128 EPROM provides 16K bytes of mass-storage space. When it is full (a nondestructive EPROM FULL error will tell you), simply erase the present EPROM or insert another. Finally, since this pseudo-mass storage exists in directly addressable memory space rather than cassettes or disks, it runs at full processor speed and stored application programs are instantly accessible.

BASIC-52 bridges the gap between expensive, intelligent control capabilities and hard-to-justify, price-sensitive control applications. BASIC-52's full floating-point BASIC is fast and efficient enough for the most complicated tasks, while its cost-effective design lets it be considered for many new areas of implementation.

I'm bullish on the BCC-52 board, and you can expect to see it in future Circuit Cellar projects. With so much power and convenience, I can accomplish quite a bit in a few lines of code—especially since that's all I may ever write.

The BCC-52 Board

The BCC-52 is a single-board controller/development system. Shown as a prototype in photo 1 and as a schematic in figure 3, this 17-chip circuit fits in a compact 4½ by 6½ inches (the same size as the Term-Mite smart terminal [see photo 2], if you want a two-board complete system—see my columns in the January and February 1984 issues of BYTE). It contains RAM/EPROM, an EPROM programmer, three parallel ports, and two serial ports.

The BCC-52 board has five main sections: processor, address decoding and memory, parallel I/O (input/output), serial I/O, and EPROM programmer.

The BCC-52 board is based on the 8052AH-BASIC chip, a preprogrammed version of Intel's 8052AH microcontroller (see figure 4). The 8052AH is the newest of Intel's 8-bit microcontroller-chip series, also known as the MCS-51 family.

The 8052AH contains 8K bytes of on-chip ROM, 256 bytes of RAM, three 16-bit counter/timers, six interrupts, and 32 I/O lines. In the 8052AH-BASIC chip, the ROM is a masked BASIC interpreter, and the I/O lines are redefined to address, data, and control lines. Figure 5a illustrates the 8052AH-BASIC chip pinout.

The 8052AH-BASIC chip has a 16-bit address and an 8-bit data bus (the 8 least significant address bits [AD0–AD7] and the data bus [D0–D7] are multiplexed together, similar to

(continued)

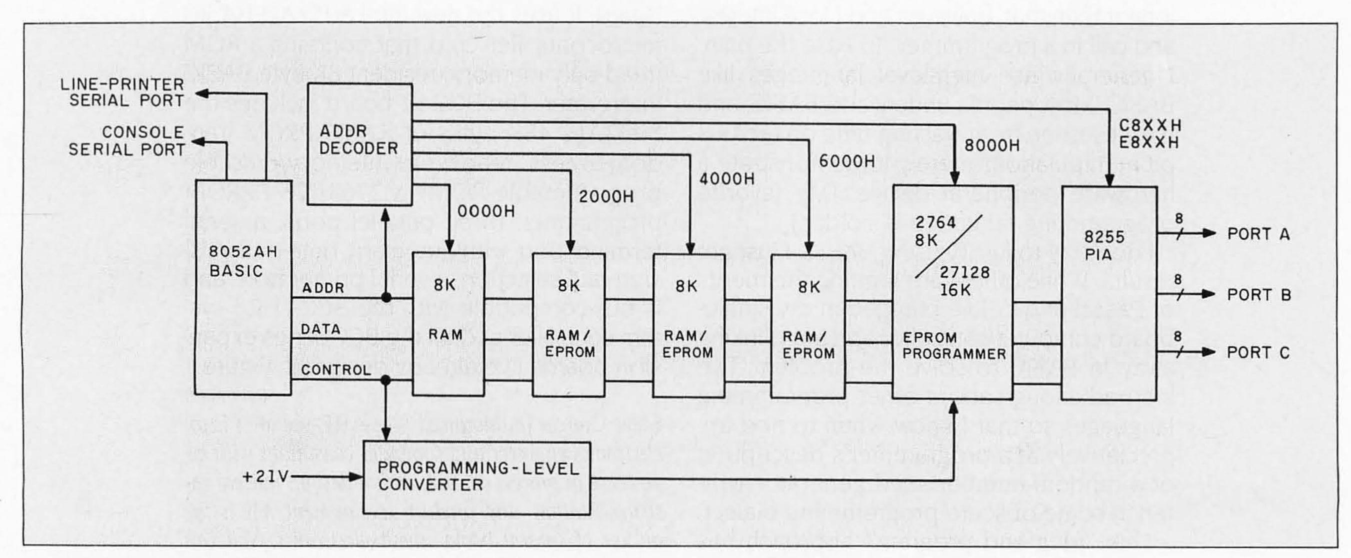


Figure 1: *Block diagram of the Circuit Cellar* BASIC-52 *computer/controller board.*

Command	Function
RUN	Execute a program
CONT	Continue after a stop or Control-C
LIST	List program to the console device
LIST#	List program to serial printer
NEW	Erase the program stored in RAM
NULL	Set null count after carriage return/line feed
RAM	Evoke RAM mode, current program in read/write memory
ROM	Evoke ROM mode, current program in ROM/EPROM
XFER	Transfer a program from ROM/EPROM to RAM
PROG	Save the current program in EPROM
PROG1	Save data-transmission-rate information in EPROM
PROG2	Save data-transmission-rate information in EPROM and execute program after reset
FPROG	Save the current program in EPROM using the intelligent algorithm
FPROG1	Save data-transmission-rate information in EPROM using the intelligent algorithm
FPROG2	Save data-transmission-rate information in EPROM and execute program after reset, use intelligent algorithm

Statement	Function
BAUD	Set data-transmission rate for line-printer port
CALL	Call assembly-language program
CLEAR	Clear variables, interrupts, and strings
CLEARS	Clear stacks
CLEAR1	Clear interrupts
CLOCK1	Enable real-time clock
CLOCK0	Disable real-time clock
DATA	Data to be read by READ statement
READ	Read data in DATA statement
RESTORE	Restore read pointer
DIM	Allocate memory for arrayed variables
DO	Set up loop for WHILE or UNTIL
UNTIL	Test DO loop condition (loop if false)
WHILE	Test DO loop condition (loop if true)
END	Terminate program execution
FOR-TO-{STEP}	Set up FOR...NEXT loop
NEXT	Test FOR...NEXT loop condition
GOSUB	Execute subroutine
RETURN	Return from subroutine
GOTO	GOTO program line number
ON GOTO	Conditional GOTO
ON GOSUB	Conditional GOSUB
IF-THEN-{ELSE}	Conditional test
INPUT	Input a string or variable
LET	Assign a variable or string a value (LET is optional)
ONERR	ONERR or GOTO line number
ONTIME	Generate an interrupt when time is equal to or greater than ONTIME argument; line number is after comma
ONEX1	GOSUB to line number following ONEX1 when INT1 pin is pulled low
PRINT	Print variables, strings, or literals, P. is shorthand for print
PRINT#	Print to software serial port
PH0.	Print hexadecimal mode with zero suppression
PH1.	Print hexadecimal mode with no zero suppression
PH0.#	PH0.# to line printer
PH1.#	PH1.# to line printer
PUSH	Push expressions on argument stack

Statement	Function
POP	Pop argument stack to variables
PWM	Pulse-width modulation
REM	Remark
RETI	Return from interrupt
STOP	Break program execution
STRING	Allocate memory for strings
UI1	Evoke user console input routine
UI0	Evoke BASIC console input routine
UO1	Evoke user console output routine
UO0	Evoke BASIC console output routine

Operator	Function
CBY( )	Read program memory
DBY( )	Read/assign internal data memory
XBY( )	Read/assign external data memory
GET	Read console
IE	Read/assign IE register
IP	Read/assign IP register
PORT1	Read/assign I/O port 1 (P1)
PCON	Read/assign PCON register
RCAP2	Read/assign RCAP2 (RCAP2H:RCAP2L)
T2CON	Read/assign T2CON register
TCON	Read/assign TCON register
TMOD	Read/assign TMOD register
TIME	Read/assign real-time clock
TIMER0	Read/assign TIMER0 (TH0:TL0)
TIMER1	Read/assign TIMER1 (TH1:TL1)
TIMER2	Read/assign TIMER2 (TH2:TL2)
+	Addition
/	Division
**	Exponentiation
*	Multiplication
−	Subtraction
.AND.	Logical AND
.OR.	Logical OR
.XOR.	Logical exclusive OR

Stored Constant	
PI	PI – 3.1415926

Operators—Single Operand	
ABS( )	Absolute value
NOT( )	One's complement
INT( )	Integer
SGN( )	Sign
SQR( )	Square root
RND	Random number
LOG( )	Natural log
EXP( )	"e" (2.7182818) to the X
SIN( )	Returns the sine of argument
COS( )	Returns the cosine of argument
TAN( )	Returns the tangent of argument
ATN( )	Returns the arctangent of argument

Figure 2: *Detailed description of the Intel* 8052AH BASIC-52 *programming language.*

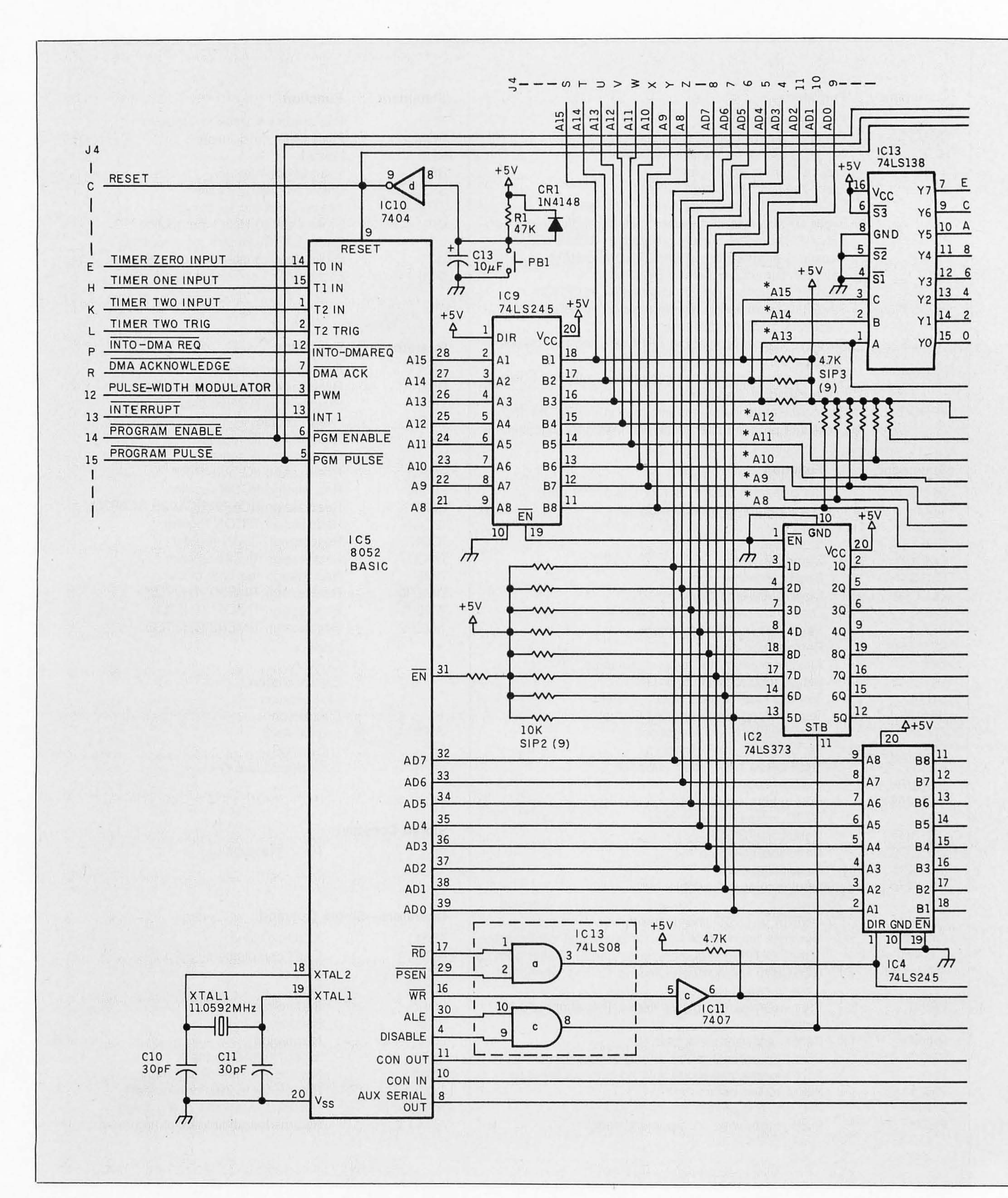
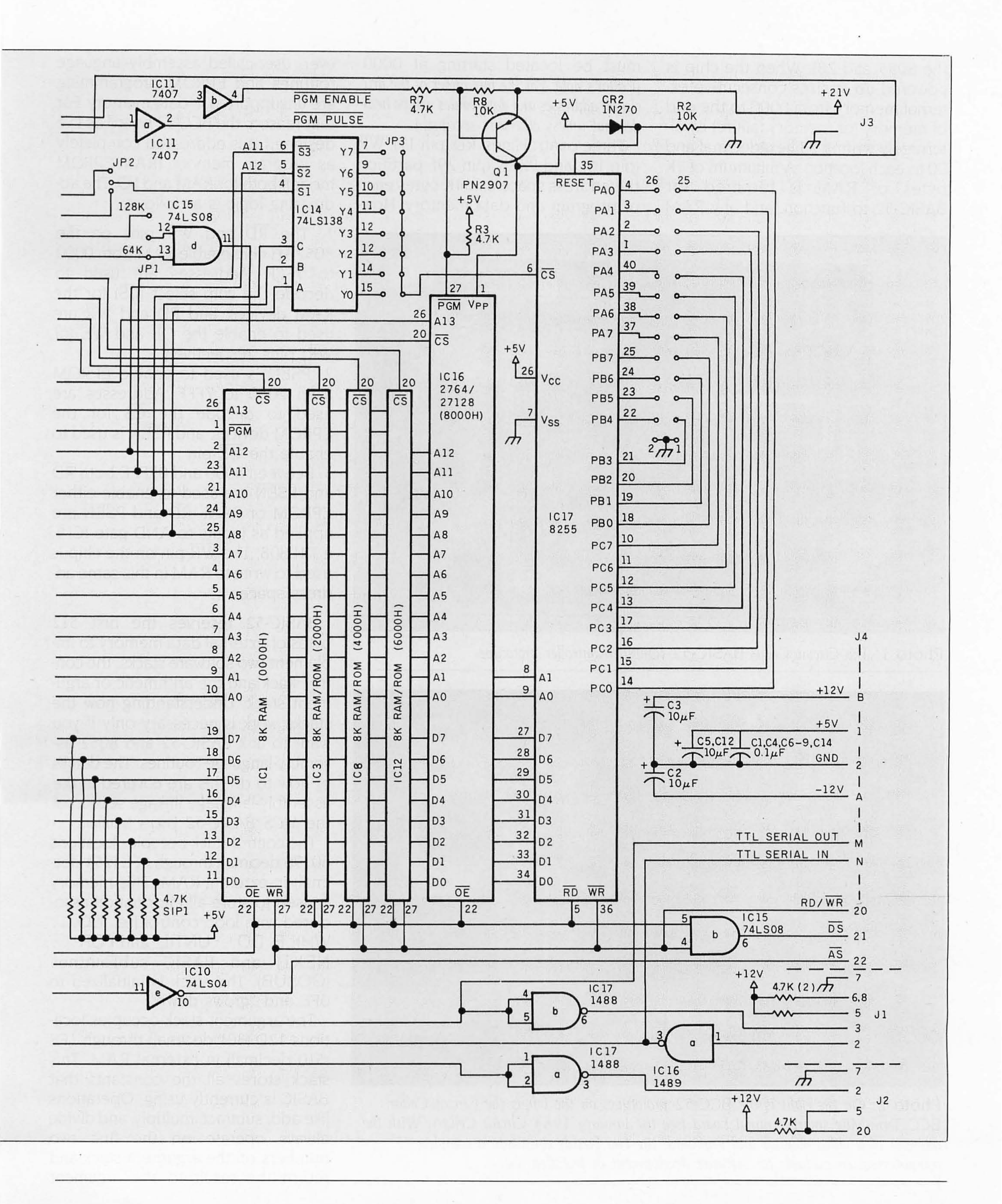


Figure 3: *Schematic diagram of the BCC-52 board.*


IC11
7407
IC11
7407
JP2
128K
64K
JP1
IC15
74LS08
PGM ENABLE
PGM PULSE
A11
A12
S3
S2
S1
IC14
74LS138
C
B
A
Y7
Y6
Y5
Y4
Y3
Y2
Y1
Y0
JP3
R7
4.7K
R8
10K
+5V
R3
4.7K
Q1
PN2907
CR2
1N270
R2
10K
+21V
J3
RESET
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
PC7
PC6
PC5
PC4
PC3
PC2
PC1
PC0
IC17
8255
CS
PGM
VPP
A13
IC16
2764/
27128
(8000H)
VCC
VSS
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
D7
D6
D5
D4
D3
D2
D1
D0
OE
WR
RD
IC1
8K RAM (0000H)
IC3
8K RAM/ROM (2000H)
IC8
8K RAM/ROM (4000H)
IC12
8K RAM/ROM (6000H)
4.7K
SIP1
IC10
74LS04
J4
+12V
+5V
GND
-12V
C3
10μF
C5,C12
10μF
C1,C4,C6-9,C14
0.1μF
C2
10μF
TTL SERIAL OUT
TTL SERIAL IN
RD/WR
DS
AS
IC15
74LS08
IC17
1488
4.7K (2)
J1
IC16
1489
J2
4.7K

the 8085 and Z8). When the chip is powered up, it sizes consecutive external memory from 0000 to the end of memory (or memory failure) by alternately writing 55 hexadecimal and 00 to each location. A minimum of 1K bytes of RAM is required for BASIC-52 to function, and any RAM must be located starting at 0000. [*Editor's note: For the remainder of the article, all addresses and data values will be hexadecimal unless otherwise specified.*]

Three control lines, RD (pin 17), WR (pin 16), and PSEN (pin 29), partition the address space as 64K bytes each of program and data memory. However, user-called assembly-language routines and EPROM programming are unsupported in data memory. For that reason, the BCC-52 board as I've designed it is addressed completely as program memory (RAM/EPROM mode), both for RAM and I/O. The addressing logic is as follows:

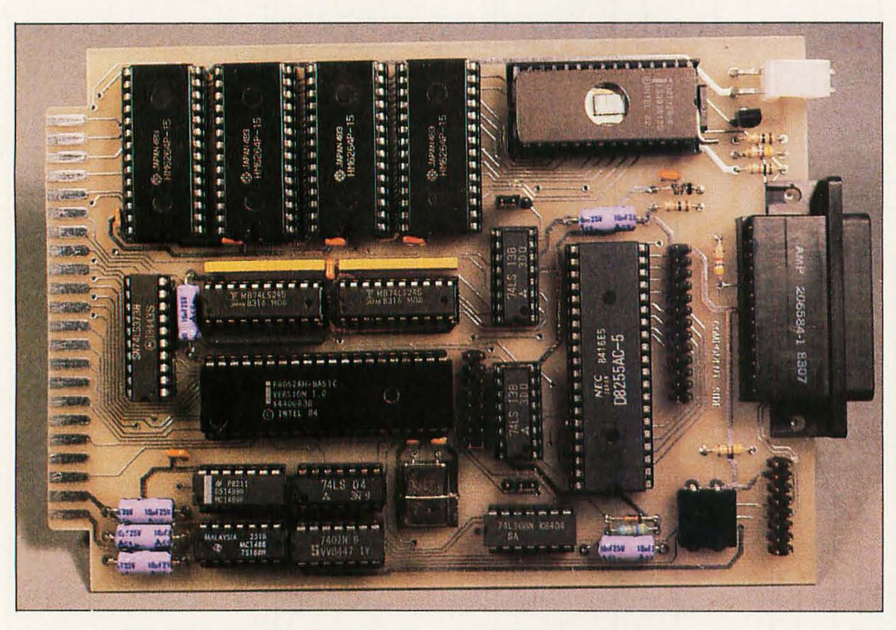


Photo 1: *The Circuit Cellar* BASIC-52 *computer/controller prototype.*

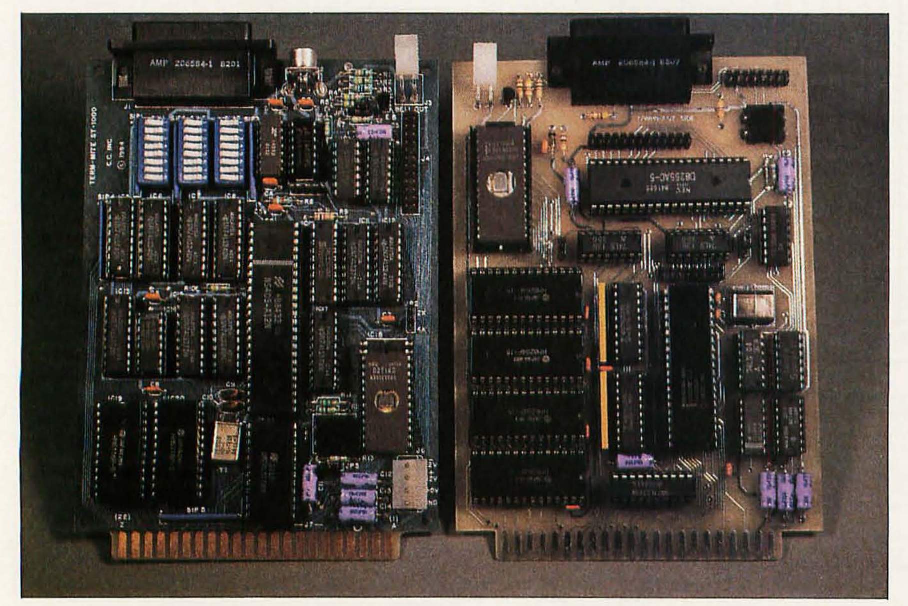


Photo 2: *On the right is the* BCC-52 *prototype; on the left is the Circuit Cellar* BCC *Term-Mite smart-terminal board (see the January* 1984 *Circuit Cellar). With the addition of a video monitor and keyboard, the two boards constitute a complete computer system suitable for software development or installed use.*

1. The RD and WR pins on the 8052AH chip enable RAM from 0000 to 7FFF. Addresses are used to decode the chip select (CS) for the RAM devices, and RD and WR are used to enable the OE and WE (or WR) pins, respectively.
2. PSEN is used to enable EPROM from 2000 to 7FFF. Addresses are used to decode the CS for the EPROM devices, and PSEN is used to enable the OE pin.
3. Between 8000 and 0FFFF, both RD and PSEN are used to enable either EPROM or RAM. RD and PSEN are applied as inputs to AND gate IC15, a 74LS08. The WR pin on the chip is used to write to RAM in this same address space.

BASIC-52 reserves the first 512 bytes of external data memory to implement two software stacks: the control stack and the arithmetic or argument stack. Understanding how the stacks work is necessary only if you want to link BASIC-52 and 8052 assembly-language routines. The details of how to do this are covered in the assembly-language linkage section of the *MCS BASIC-52 User's Manual.*

The control stack occupies locations 60 (96 decimal) through 0FE (254 decimal) in external RAM. This memory is used to store all information associated with loop control (i.e., DO. . . WHILE, DO. . .UNTIL, and FOR. . . NEXT) and BASIC subroutines (GOSUB). The stack is initialized to 0FE and "grows down."

The argument stack occupies locations 12D (301 decimal) through 1FE (510 decimal) in external RAM. This stack stores all the constants that BASIC is currently using. Operations like add, subtract, multiply, and divide always operate on the first two numbers on the argument stack and return the result to the argument

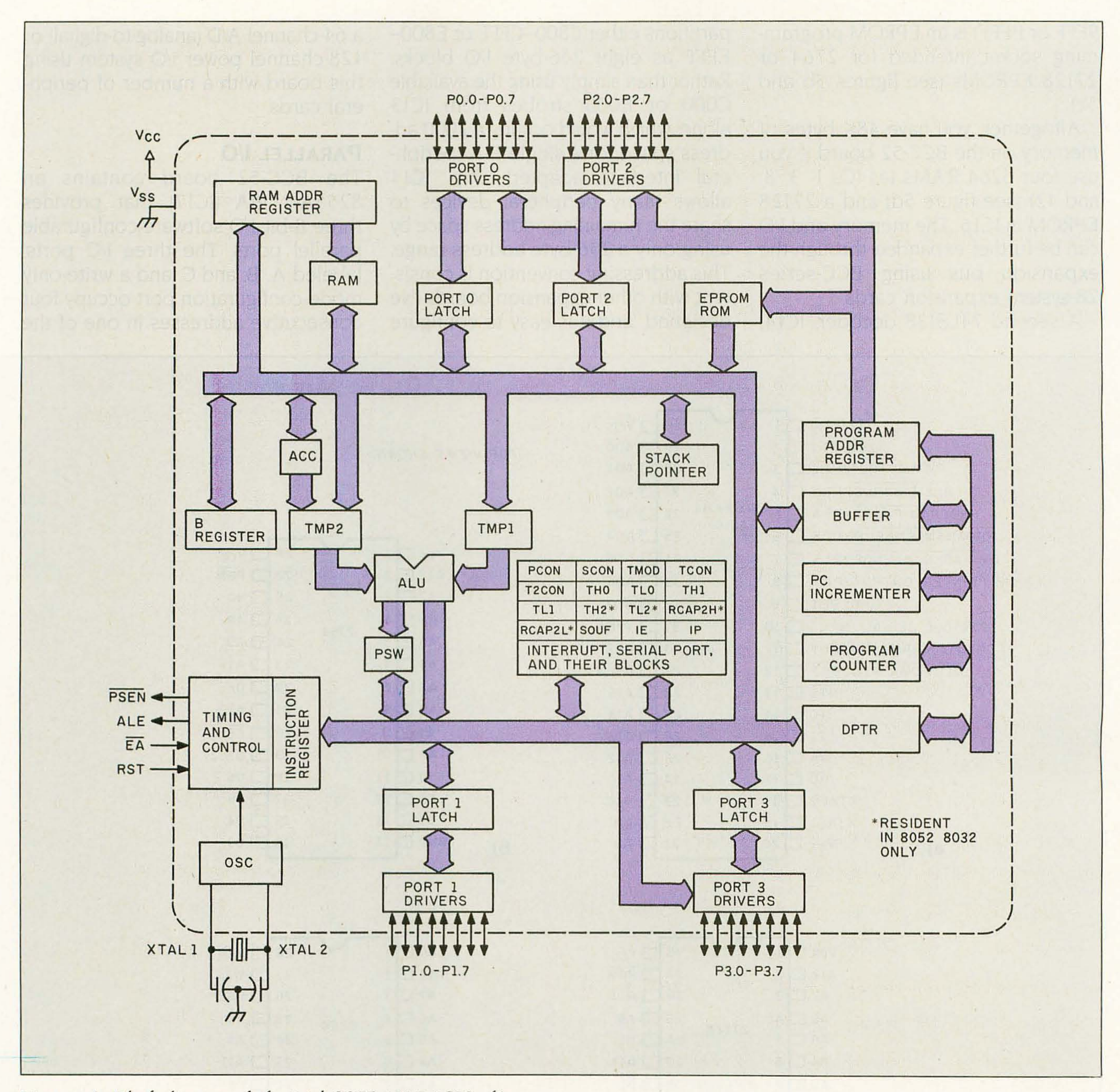


Figure 4: *Block diagram of the Intel* 8052AH-BASIC *chip.*

stack. The argument stack is initialized to 1FE and "grows down" as more values are placed on it. Each floating-point number placed on the argument stack requires 6 bytes of storage.

The stack pointer on the 8052AH (special-function register, SP) is initialized to 4D (77 decimal). The 8052AH's stack pointer "grows up" as additional values are placed on the stack.

ADDRESS DECODING

The three most significant address lines (A13–A15) are connected to a 74LS138 decoder chip, IC13, which separates the addressable range into eight 8K-byte memory segments, each with its own chip select (Y0–Y7). The four least significant chip selects are connected to 28-pin, 64K-bit (8K by 8) memory devices, either 2764 EPROMs or 6264 static RAMs. IC1, addressed at 0000, must be RAM in order for BASIC-52 to function. IC locations 3 (2000–3FFF), 11 (4000–5FFF), and 12 (6000–7FFF) can use either RAM or EPROM. IC16 (8000–

(continued)

9FFF or BFFF) is an EPROM programming socket intended for 2764 or 27128 EPROMs (see figures 5b and 5c).

Altogether, you have 48K bytes of memory on the BCC-52 board if you use four 6264 RAMs (as ICs 1, 3, 8, and 12) (see figure 5d) and a 27128 EPROM in IC16. The memory and I/O can be further expanded through the expansion bus using BCC-series Z8-system expansion cards.

A second 74LS138 decoder, IC14, partitions either C800–CFFF or E800–EFFF as eight 256-byte I/O blocks. Rather than simply using the available C000 or E000 strobes from IC13 alone, which would occupy a 2000 address space for a single PIA (peripheral interface adapter) chip, IC14 allows many peripheral devices to share the remaining address space by using only a 256-byte address range. This addressing convention is consistent with other expansion boards I've designed, and it is easy to configure a 64-channel A/D (analog-to-digital) or 128-channel power I/O system using this board with a number of peripheral cards.

PARALLEL I/O

The BCC-52 board contains an 8255A-5 PIA (IC17) that provides three 8-bit I/O software-configurable parallel ports. The three I/O ports, labeled A, B, and C, and a write-only mode-configuration port occupy four consecutive addresses in one of the

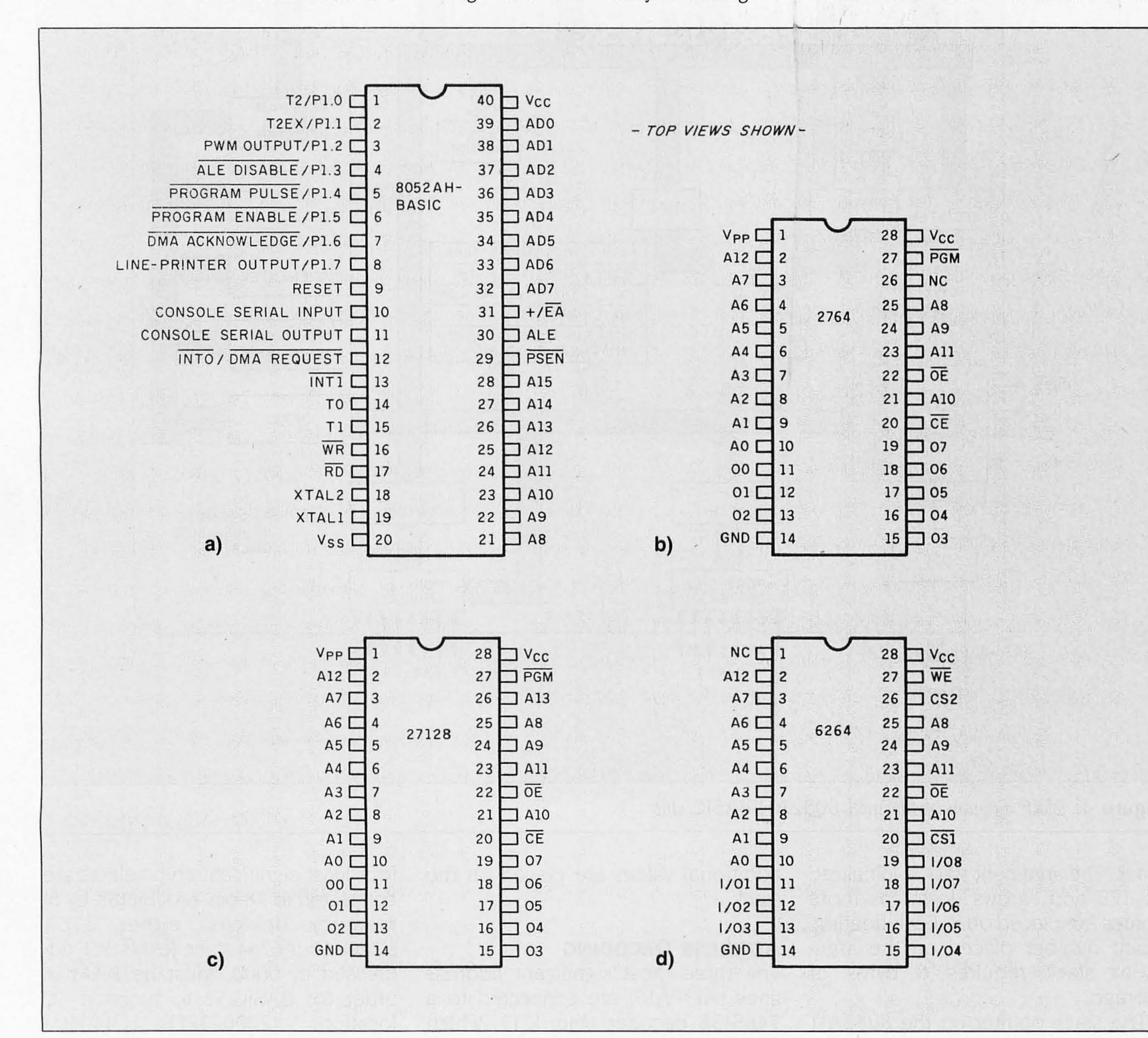


Figure 5: *Pinouts for (a) the* 8052AH-BASIC *chip, (b) the* 2764 8K-*byte* EPROM, *(c) the* 27128 16K-*byte* EPROM, *and (d) the* 6264 8K-*byte* RAM.

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eight jumper-selectable I/O blocks. With C000 selected and pin 17 of IC14 (Y0) jumpered to pin 6 of IC17 (at JP3), the range would be C800–C803. Using the XBY() operator in BASIC, data can be written to and read from this PIA. (You are probably more familiar with PEEK and POKE. PEEK (C802H) is accomplished with XBY (C802H), and POKE C902H,A is XBY(C802H) = A.) I won't belabor the discussion on the 8255. I have used it many times in Circuit Cellar projects and refer you to the manufacturer's data sheets.

The three parallel ports and ground are connected to a 26-pin flat ribbon-cable connector. The outputs are TTL (transistor-transistor logic)-compatible.

SERIAL I/O

Two serial ports are found on the BCC-52 board. One is for the console I/O terminal (IC5 pins 10 and 11); the other is an auxiliary serial output (IC5 pin 8) frequently referred to as the line-printer port. When using an 11.0592-megahertz (MHz) crystal, the console port does automatic data-transmission-rate determination on power-up (a preset data-transmission rate can alternatively be stored in EPROM as well). I've used it at 19,200 bits per second (bps) with no degradation in operation.

The BAUD[expr] statement is used to set the data-transmission rate for the line-printer port. In order for this statement to properly calculate the data-transmission rate, the crystal (special-function operator—XTAL) must be correctly assigned (e.g., XTAL = 9000000). BASIC-52 assumes a crystal value of 11.0592 MHz if no XTAL value is assigned.

The main purpose of the software line-printer port is to let you make a hard copy of program listings and/or data. The command LIST# and the statement PRINT# direct outputs to the software line-printer port. If the BAUD[expr] statement is not executed before a LIST# or PRINT# command/statement is entered, the output to the software line-printer port will be at about 1 bps, and it will take a long time to output something. It is necessary to assign a data-transmission rate to the software line-printer port before using LIST# or PRINT#. The maximum data-transmission rate that can be assigned by the BAUD[expr] statement depends on the crystal, but 4800 bps is a reasonable maximum rate.

MC1488 and 1489 level shifters (ICs 6 and 7) convert the TTL levels from the console and line-printer ports to RS-232C. (The TTL serial lines are also connected to the bus to allow use of the Term-Mite smart-terminal board without RS-232C voltages.) The BCC-52 board requires only about 200 milliamperes (mA) at +5 volts (V) to function. The voltage required for external RS-232C communication is ±12 V; that required for EPROM programming is +21 V.

EPROM PROGRAMMER

One of the more unique and powerful features of the BCC-52 board is its

(continued)

■Mode Selection (goes with figure 5b)

Mode \ Pins	CE (20)	OE (22)	PGM (27)	V_{PP} (1)	V_{CC} (28)	Outputs (11–13, 15–19)
Read	V_{IL}	V_{IL}	V_{IH}	V_{CC}	V_{CC}	Dout
Standby	V_{IH}	×	×	V_{CC}	V_{CC}	High Z
Program	V_{IL}	×	V_{IL}	V_{PP}	V_{CC}	Din
Program Verify	V_{IL}	V_{IL}	V_{IH}	V_{PP}	V_{CC}	Dout
Program Inhibit	V_{IH}	×	×	V_{PP}	V_{CC}	High Z

■Mode Selection (goes with figure 5c)

Mode \ Pins	CE (20)	OE (22)	PGM (27)	V_{PP} (1)	V_{CC} (28)	Outputs (11–13, 15–19)
Read	V_{IL}	V_{IL}	V_{IH}	V_{CC}	V_{CC}	Dout
Standby	V_{IH}	×	×	V_{CC}	V_{CC}	High Z
Program	V_{IL}	×	V_{IL}	V_{PP}	V_{CC}	Din
Program Verify	V_{IL}	V_{IL}	V_{IH}	V_{PP}	V_{CC}	Dout
Program Inhibit	V_{IH}	×	×	V_{PP}	V_{CC}	High Z

■Mode Selection (goes with figure 5d)

$\overline{WE}$	$\overline{CS_1}$	CS_2	$\overline{OE}$	Mode	I/O Pin
×	H	×	×	Not Selected (Power Down)	High Z
×	×	L	×		High Z
H	L	H	H	Output Disabled	High Z
H	L	H	L	Read	Dout
L	L	H	H	Write	Din
L	L	H	L		Din

×: don't care

ability to execute and save programs in an EPROM. The 8052AH chip actually generates all the timing signals needed to program 2764/128 EPROMs. Saving programs in EPROMs is a much more attractive and reliable alternative to cassette tape, especially in control and/or noisy environments.

The entire EPROM programming circuitry consists of two 7407 open-collector drivers and a single transistor circuit that switches between +5 V and 21 V (CR2, connected to the collector of the transistor should be a germanium diode like a 1N270).

Port 1, bit 4 (IC5 pin 5) is used to provide a 1- or 50-millisecond (ms) programming pulse. The length of the pulse is determined by whether we are programming Intel fast-program EPROMs or generic 2764s and 27128s. BASIC-52 calculates the length of the pulse from the assigned crystal value. The accuracy of this pulse is within 10 processor clock cycles. This pin is normally in a logical high (1) state. It is asserted low (0) to program the EPROMs.

Port 1, bit 5 (IC5 pin 6) is used to enable the EPROM programming voltage. This pin is normally in a logical high (1) state. Prior to the EPROM programming operation, this pin is brought to a logical low (0) state, and it is used to turn on the high voltage (21 V) required to program the EPROMs on or off.

BASIC-52 saves several programs on a single EPROM. In fact, it can save as many programs as the size of the EPROM permits. The programs are stored sequentially in the EPROM, and any program can be retrieved and executed. This sequential storage of programs is referred to as the EPROM file. The following commands permit you to generate and manipulate the EPROM file.

RAM and ROM[integer] tell the BASIC-52 interpreter whether to select the current program (the one that will be displayed during a LIST# command and executed when RUN is typed) out of RAM or EPROM. The RAM address is assumed to be 200 (512 decimal), and the EPROM address begins at 8010 (32,784 decimal).

When RAM is entered, BASIC-52 selects the current program from RAM. This is usually considered the normal mode of operation and is the mode that most users employ to interact with the command interpreter.

When ROM[integer] is entered, BASIC-52 selects the current program out of EPROM. If no integer is typed after the ROM command (i.e., ROM(cr)), BASIC-52 defaults to ROM 1. Since the programs are stored sequentially in EPROM, the integer following the ROM command selects which program you want to run or list. If you attempt to select a program that does not exist (i.e., you type in ROM 8 and only six programs are stored in the EPROM), the message Error: Prom Mode will be displayed. The error is nondestructive, and you can retype the correct command.

BASIC-52 does not transfer the program from EPROM to RAM when the ROM mode is selected, and you cannot edit a program in ROM. Attempting to do so will result in an error message.

Since the ROM command does not transfer a program to RAM, it is possible to have different programs in ROM and RAM simultaneously. You can flip back and forth between the two modes at any time. Another benefit of not transferring a program to RAM is that all the RAM can be used for variable storage if the program is stored in EPROM. The system-control values, MTOP and FREE, always refer to RAM.

The XFER (transfer) command transfers the currently selected program in EPROM to RAM and then selects the RAM mode. After the XFER command is executed, you can edit the program in the same manner any RAM program can be edited.

The PROG command programs the resident EPROM with the current program (this is the only time that the +21-V programming voltage needs to be applied). The current program can reside in either RAM or EPROM. After PROG is typed, BASIC-52 displays the number in the EPROM file the program will occupy.

Normally, after power is applied to

the BASIC-52 device, you must type a space character to initialize the 8052AH's console port. As a convenience, BASIC-52 contains a PROG1 command. This command programs the resident EPROM with the data-transmission-rate information. The next time the MCS BASIC-52 device is powered up, i.e., reset, the chip will read this information and initialize the serial port with the stored data-transmission rate. The sign-on message will be sent to the console immediately after the BASIC-52 device completes its reset sequence. The space character no longer needs to be typed.

The PROG2 command does everything the PROG1 command does, but instead of signing on and entering the command mode, the BCC-52 board immediately begins executing the first program stored in the resident EPROM.

By using the PROG2 command, it is possible to run a program from a reset condition and never connect the BCC-52 board to a console. In essence, saving PROG2 information is equivalent to typing ROM 1 and RUN in sequence. This is ideal for control applications, where it is not always possible to have a terminal present. In addition, this feature lets you write a special initialization sequence in BASIC or assembly language and generate a custom sign-on message for specific applications.

Powering Up the Board

The best way to check out the BCC-52 board is to run it with the minimum hardware first. With only ICs 1, 2, 4–7, 9–11, 13, and 15 installed, we have an 8K-byte RAM-only system. After applying power, BASIC-52 clears the internal 8052AH memory; initializes the internal registers and pointers; and tests, clears, and sizes the external memory.

BASIC-52 then assigns the top of external RAM to the system-control value (MTOP) and uses this number as the random-number seed. BASIC-52 assigns the default-crystal value, 11.0592 MHz, to the system-control value (XTAL) and uses this default value to calculate all time-dependent functions, like the EPROM programming timer and the interrupt-driven real-time clock. Finally, BASIC-52 checks external memory location 8000 to see if the data-transmission-rate information is stored. If the data-transmission rate is stored, BASIC-52 initializes the data-transmission-rate generator (the 8052AH's special-function register, T2CON) with this information and signs on. If not, BASIC-52 interrogates the serial-port input and waits for a space character to be typed (automatic data-transmission-rate detection).

If you have entered nothing on the console device, BASIC-52 will appear inoperative to the uninitiated. Simply type a space, and the console device should display the following:

```
*MCS-52(tm) BASIC Vx.x*
READY
>
```

To see if the processor is operating correctly, we type the following:

```
>PRINT XTAL, TMOD, TCON,
 T2CON
```

BASIC-52 should respond with the control and special-function values:

```
11059200 16 244 52
>
```

A Word About the BASIC

As I mentioned earlier, BASIC-52 is oriented toward process control and is significantly more powerful than a tiny BASIC. Since most of you are familiar with BASIC, I will not describe individual instructions like DO... WHILE and FOR...NEXT. Instead, I'd like to point out the pertinent features that demonstrate the exceptional small-package performance of the BCC-52 board.

MCS BASIC-52 contains a minimum-level line editor. Once a line is entered, you cannot change the line without retyping it. However, it is possible to delete characters while a line is in the process of being entered. This is done by inserting a rubout or delete character (7F). The rubout character will cause the last character entered to be erased from the text input buffer. Additionally, pressing Control-D will cause the entire line to be erased.

Variables and Expressions

The range of numbers that can be represented in BASIC-52 (in decimal) is +1E−127 to +0.99999999E+127.

It has eight digits of significance. Numbers are internally rounded to fit this precision. Numbers can be entered and displayed in four formats: integer, decimal, hexadecimal, and exponential, for example, 129, 34.98, OA6EH, 1.23456E+3.

Integers are numbers that range from −32,768 to +32,767 decimal. All integers can be entered in either decimal or hexadecimal format. A hexadecimal number is indicated by placing the letter "H" after the number. When an operator like AND requires an integer, BASIC-52 will truncate the fraction portion of the number so that it will fit the integer format. All line numbers are integers.

A variable can be either a letter (e.g. A, X, I), a letter followed by a number (e.g., Q1, T7, L3), a letter followed by a one-dimensioned expression (e.g., J(4), G(A+6), I(10*SIN(X))), or a letter followed by a number followed by a one-dimensioned expression (e.g., A1(8), P7(DBY(9)), W8(A+B)). Variables with a one-dimensioned expression are called dimensioned or arrayed variables. Variables that involve only a letter or a letter and a number are called scalar variables.

BASIC-52 allocates variables in a static manner. Each time a variable is used, BASIC-52 allocates 8 bytes specifically for that variable. This memory cannot be deallocated on a variable-by-variable basis. If you execute a statement like Q=3, later on you cannot tell BASIC-52 that the variable Q no longer exists and free up the 8 bytes of memory that belong to Q. You can clear the memory allocated to variables with a CLEAR statement.

Relative to a dimensioned variable, it takes BASIC-52 much less time to find a scalar variable. That's because a scalar variable has no expression to

(continued)

evaluate. If you want to make a program run as fast as possible, use dimensioned variables only when you have to. Use scalar variables for intermediate variables, then assign the final result to a dimensioned variable.

An expression is a logical mathematical term that involves operators (both unary and dyadic), constants, and variables. Expressions can be simple or quite complex, e.g., 12* EXP(A)/100, H(1)+55, or (SIN(A)* SIN(A)+COS(A)*COS(A))/2. A standalone variable |var| or constant |const| is also considered an expression.

REAL-TIME OPERATION

After RUN is typed, all variables are set equal to zero, all BASIC-evoked interrupts are cleared, and program execution begins with the first line number of the selected program. The RUN command and the GOTO statement are the only ways you can execute a program in the command mode. Program execution can be terminated at any time by typing a Control-C on the console device.

Unlike some BASIC interpreters that allow a line number to follow the RUN command (e.g., RUN 100), BASIC-52 does not permit such a variation on the RUN command. Execution always begins with the first line number. To obtain the same functionality as the RUN[ln num], use GOTO[ln num] in the direct mode.

The CLOCK1 statement enables the software real-time clock in BASIC-52. The special-function operator time is incremented once every 5 ms after the CLOCK1 statement has been executed. The CLOCK1 statement uses timer/counter 0 in the 13-bit mode to generate an interrupt once every 5 ms. Because of this, the special-function operator time has a resolution of 5 ms.

BASIC-52 automatically calculates the proper reload value for timer/counter 0 after the crystal value has been assigned (i.e., XTAL = value. If no crystal value is assigned, MCS BASIC-52 assumes a value of 11.0592 MHz). The special-function operator time counts from 0 to 65,535.995 seconds. After reaching a count of 65,535.995 seconds, time overflows back to a count of 0.

The interrupts associated with the CLOCK1 statement cause BASIC programs to run at about 99.6 percent of normal speed. That means that the interrupt handling for the real-time-clock feature consumes only about 0.4 percent of the total processor time. This is small interrupt overhead. The CLOCK0 statement disables or turns off the real-time-clock feature.

The TIME statement is used to retrieve and/or assign a value to the real-time clock after the CLOCK1 statement enables it. TIME = 5 presets the real-time clock to 5 seconds, while ONTIME 30,100 causes the program to jump to line 100 when the real-time clock reaches 30 seconds.

Finally, PWM might be useful to literally add bells and whistles to your next control application. PWM stands for pulse-width modulation. It generates a user-defined pulse sequence on IC5 pin 3.

The statement appears as PWM 50,50,100. The first expression following PWM is the number of clock cycles the pulse will remain high. A clock cycle is equal to 1.085 microseconds (11.0592-MHz crystal). The second expression is the number of clock cycles the pulse will remain low; the third expression is the total number of cycles you want to output. All expressions in the PWM statement must be valid integers, and the minimum value for the first two expressions is decimal 20.

These are only a few of the 103 commands, statements, and operators in BASIC-52. The *User's Manual* describes them in detail.

IN CONCLUSION

This was a hard article for me to write, but not for any of the reasons you might think. So much is built into this compact board that I am impatient to use it, and it was hard to sit down and write. Unfortunately, documentation is the drudge work side of engineering.

It won't take long to put the BCC-52 board into some serious applications. It might be a single-board computer, but its configuration does not stop with a single board. The BCC-52 is BCC-series Z8-bus-compatible and can be expanded using many of the

Photo 3: *The* BCC-52 *and Term-Mite boards can be combined with other* BCC-*series peripheral devices to create control and data-acquisition systems. Here, they are combined with four* BCC-13 8-*channel*, 8-*bit* A/D *converter boards to make a* 32-*channel data-acquisition system.*

projects and boards I've already designed. For example, monitoring temperatures, controlling motors and heaters, and reporting events are adequately handled by existing power I/O, serial and parallel expansion, and A/D converter boards (see photo 3).

This BASIC-52 project has just started. Because of its power, I am inspired to further develop applications and peripheral support devices. While a specific time has not been chosen, I'll be back in a few months with the next chapter on the BCC-52.

CIRCUIT CELLAR FEEDBACK

This month's feedback is on page 376.

NEXT MONTH

Go beyond the Z80 with the Circuit Cellar SB180 computer. ■

Diagrams and data pertinent to the 8052AH-BASIC chip are reprinted courtesy of the Intel Corporation.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983.

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PART 1: THE HARDWARE

THE DSI-32 COPROCESSOR BOARD

Plug a 32-bit microcomputer into your IBM PC

Do you have scientific number-crunching problems that leave your IBM Personal Computer (PC) gasping? Do you want to learn about the 32032, one of the first commercially available 32-bit microprocessors? Or do you just want the fastest IBM PC on the block? If you answered "yes" to any of these questions, then you may be looking for the DSI-32 coprocessor board from Definicon Systems Inc.

The DSI-32 coprocessor board uses the National Semiconductor NS32032 full 32-bit CPU (central processing unit), the NS32081 high-speed FPU (floating-point processing unit), and optionally the NS32082 MMU (memory-management unit).

There are two kits. The starter kit has a 6-MHz CPU and 256K bytes of RAM (random-access read/write memory). The advanced kit has a 10-MHz CPU and 1 megabyte of RAM. The only difference between the two kits is the jumper configuration; both use the same board. If you get the starter kit, you can upgrade later to the more advanced system. Both kits have a socket for the MMU chip.

The board also has two high-speed (up to 38.4k bits per second) RS-232C serial ports and a 16-bit programmable timer. In addition, all MS-/PC-DOS facilities—such as communication ports and video and printer controllers—are available to the NS32032 via the Definicon MS-/PC-DOS interface software. The interface has special support for bit-mapped graphics-display access, including support for multiple-screen images in memory.

Did we call the DSI-32 a coprocessor? Well, that's only one way to look at it. You can also think of the IBM PC as a convenient standard chassis—supplying disk drives, power supply, display, keyboard, and expansion-board connectors—into which you can plug a powerful 32-bit microcomputer. Since Definicon's interface software runs in MS-DOS, you don't have to learn a different operating system to use the DSI-32.

A WALK AROUND THE CIRCUIT BOARD

The DSI-32 consists of a number of relatively independent functional units (see photo 1 and figures 1 through 4). The 32032 CPU (IC44) is near the center of the board. Above it is the 32201 TCU (timing control unit, IC43), which contains the clock oscillator and much of the bus-interface timing circuitry. To its right is the 32081 FPU (IC49) and to its immediate left is the MMU (IC40). Further left is the DP8409 dynamic RAM controller (IC37) and the RAM array (IC1–32). To the right of the FPU is the 2681 DUART (dual universal asynchronous receiver/transmitter, IC55), the RS-232C drivers (IC58,59,61,63, 64), and serial port connectors.

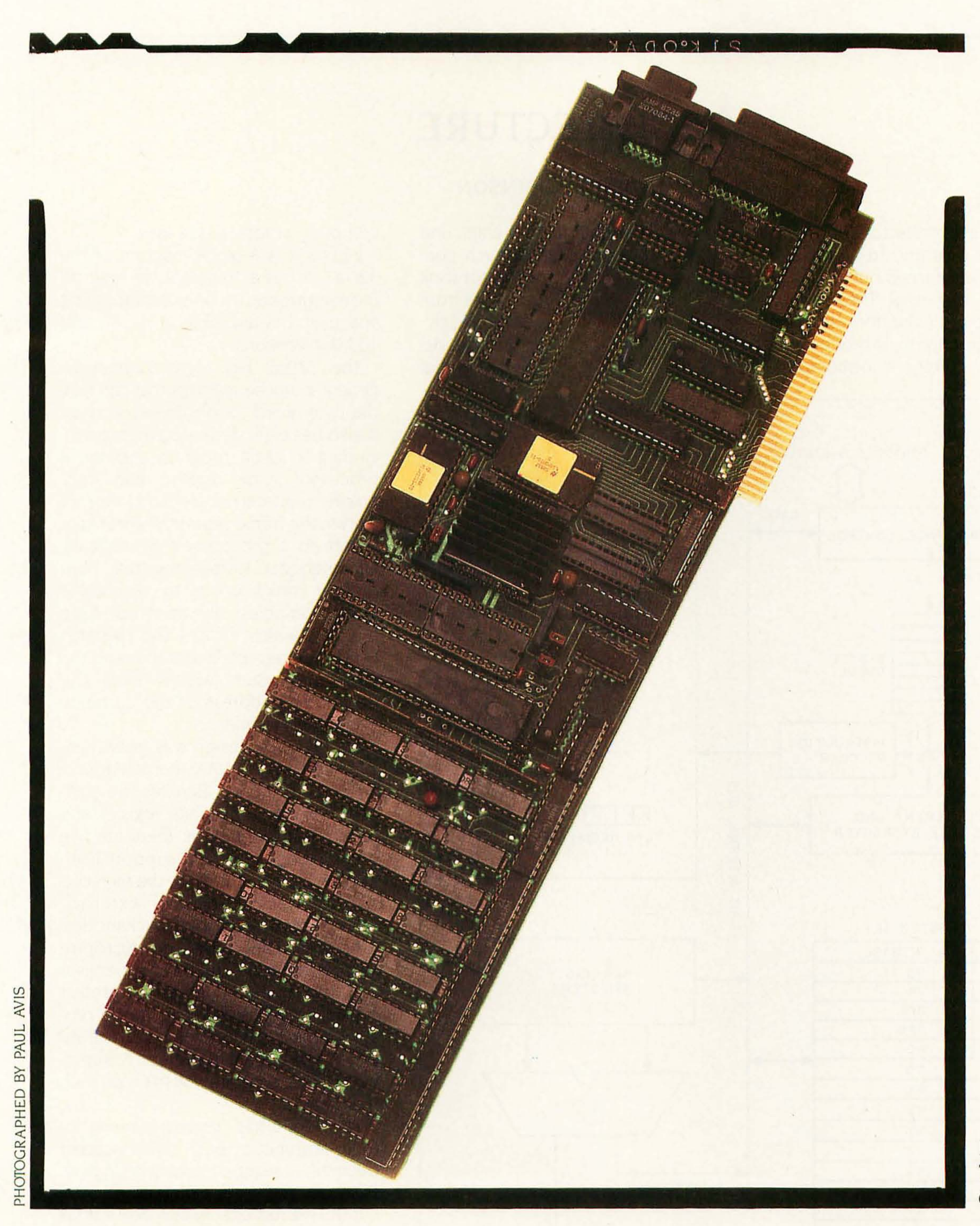
Above the DUART is a socket for user-defined peripheral devices. This socket simplifies the task of designing additional special-function daughterboards. At the far lower left are the dual bidirectional latches (74LS646, IC33–36) that buffer the data between the asynchronous 8-bit PC bus and the 32-bit internal data bus of the DSI-32. The remaining circuits perform address decoding, buffering, and control-signal generation.

There are four jumper blocks (JB1, JB2, JB3, and JB4) for selecting the operational configuration of the board. When shipped, the jumpers are in the correct position for a 32032 (full 32-bit bus) with no MMU chip in the MMU socket. Other possible configurations include the 32032 with the 32082 MMU, or just the 32016 CPU (16-bit bus). Jumpers for these configurations are shown in figure 5. The JB1 jumpers determine whether 64K-byte RAM chips or 256K-byte RAM

(continued)

Trevor G. Marshall, George Scolaro, David L. Rand, and Tom King are engineers with Definicon Systems Inc. Vincent P. Williams is president of Definicon. They can be contacted at 21042 Vintage St., Chatsworth, CA 91311.

BY TREVOR G. MARSHALL, GEORGE SCOLARO, DAVID L. RAND, TOM KING, AND VINCENT P. WILLIAMS



PHOTOGRAPHED BY PAUL AVIS

Photo 1: *The DSI-32 coprocessor board.*

ARCHITECTURE

BY PHILLIP ROBINSON

National Semiconductor's absence from the 8-bit and 16-bit microprocessor markets turned out to be an advantage in one way. The 32000 series could be designed from scratch. Other microprocessor makers often felt it was important to keep some compatibility between their earlier chips and any new designs. Free of such constraints, National Semiconductor took what it calls a "radical departure from popular trends in architectural design." The main aim was to make software development easy; to design a chip that compiler writers would love.

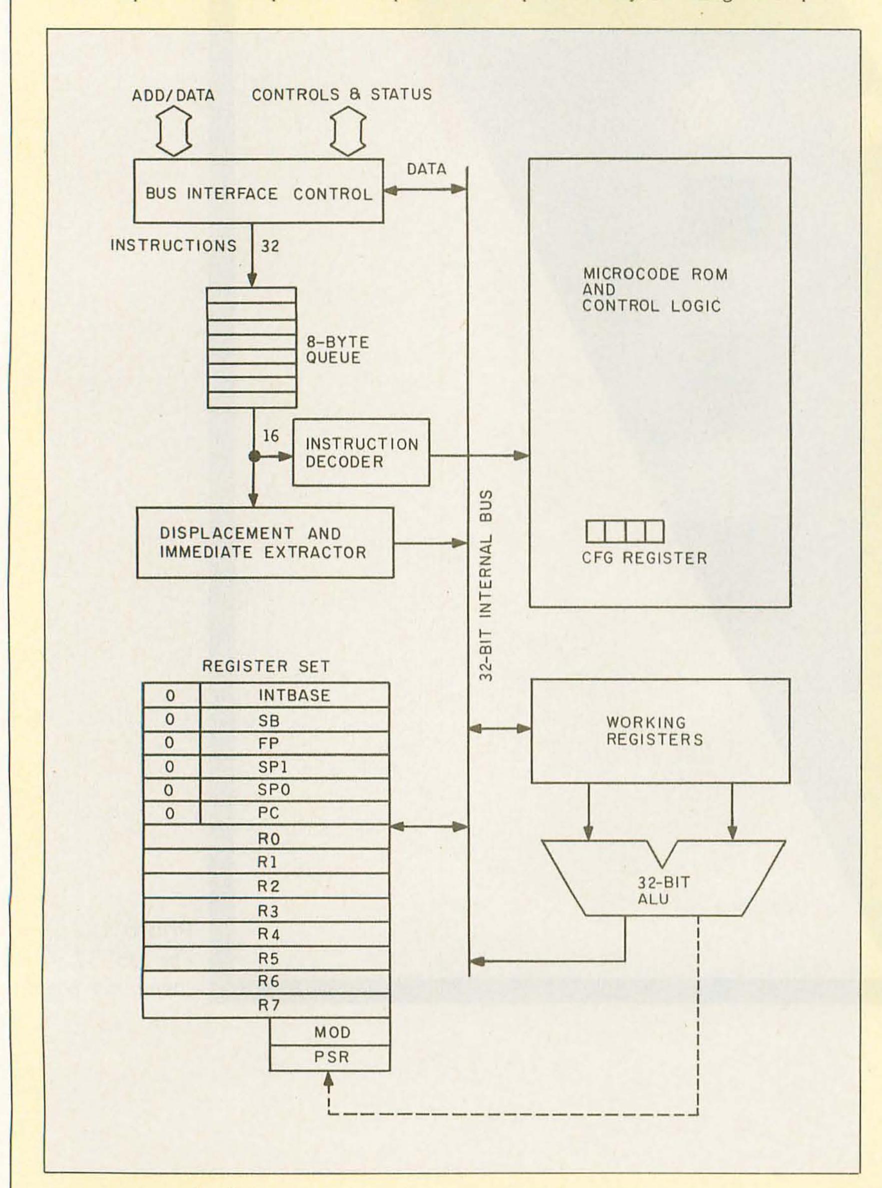


Figure A: A *block diagram of the* 32032 CPU.

Figure A is a block diagram of the 32032. It has a 16-megabyte uniform (nonsegmented) linear-addressing space and is available in 6-, 8-, and 10-MHz versions.

The 32032 has eight 32-bit-wide, general-purpose registers that can handle byte, word, or double-word data. It also has eight dedicated registers including a 32-bit program counter, a processor status register, two stack pointer registers for user and interrupt stacks, the frame-pointer register that points to a procedure's dynamically allocated local storage, the static base register (which points to relocatable global variables), the interrupt base register (which locates the dispatch table for interrupts and traps), and the module register (which holds the descriptor's address of the currently executing module).

The 32032's design was heavily influenced by the VAX, particularly its addressing modes. Besides the standard immediate, absolute, register, and register-relative modes, there are five other modes that help support high-level languages. These are the memory-space, memory-relative, external, scaled-index, and top-of-stack modes.

As with many advanced microprocessors, the 32032 has both supervisor and user operating modes. To protect operating systems, a user mode program cannot execute some instructions or access certain registers. A supervisor mode program doesn't have such restrictions.

The 32032 has customary move, integer-arithmetic, BCD (binary-coded decimal), integer-comparison, logical, Boolean, shift, bit, jump, stack, and control instructions. To that stew it adds new instructions such as MODi (modulus arithmetic) as well as new instruction groups including bit-field, array, and string operations. Finally, the 32032 has a list of floating-point, memory-management, and custom slave instructions that allow it to cooperate with other processors.

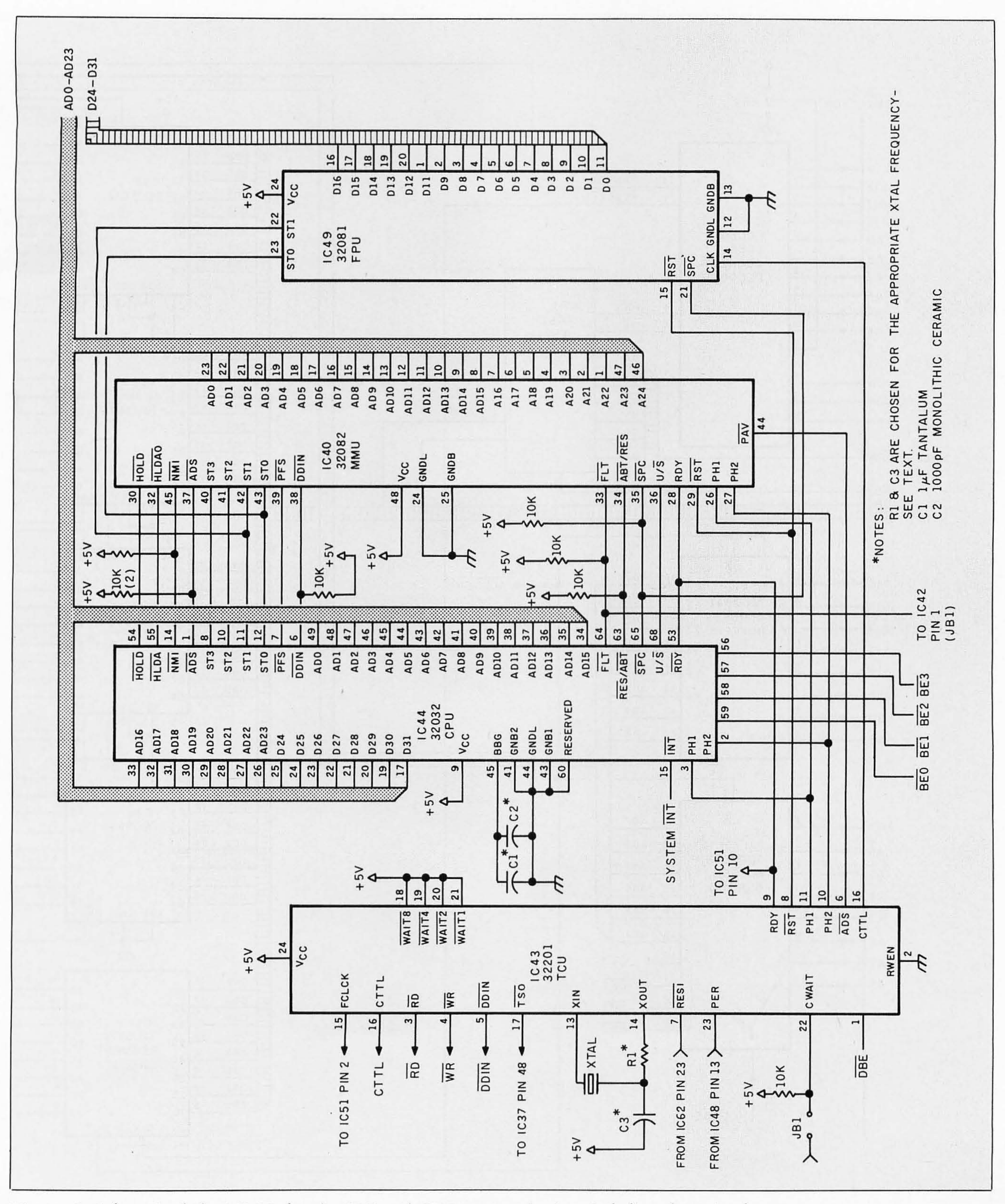


Figure 1: *Schematic of the* DSI-32 *board's* CPU *and* CPU *support circuitry, including the optional memory-management unit and floating-point unit.*

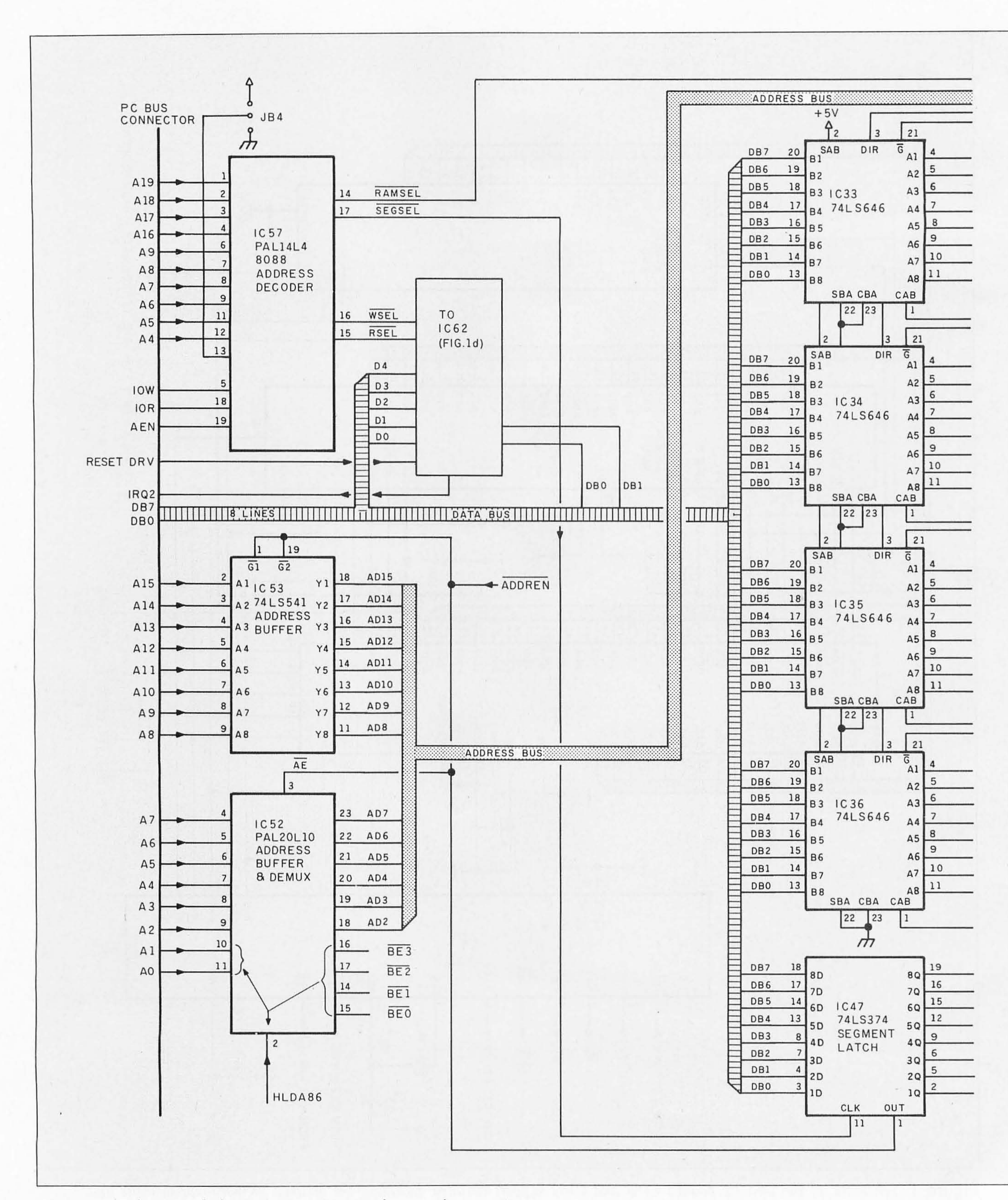
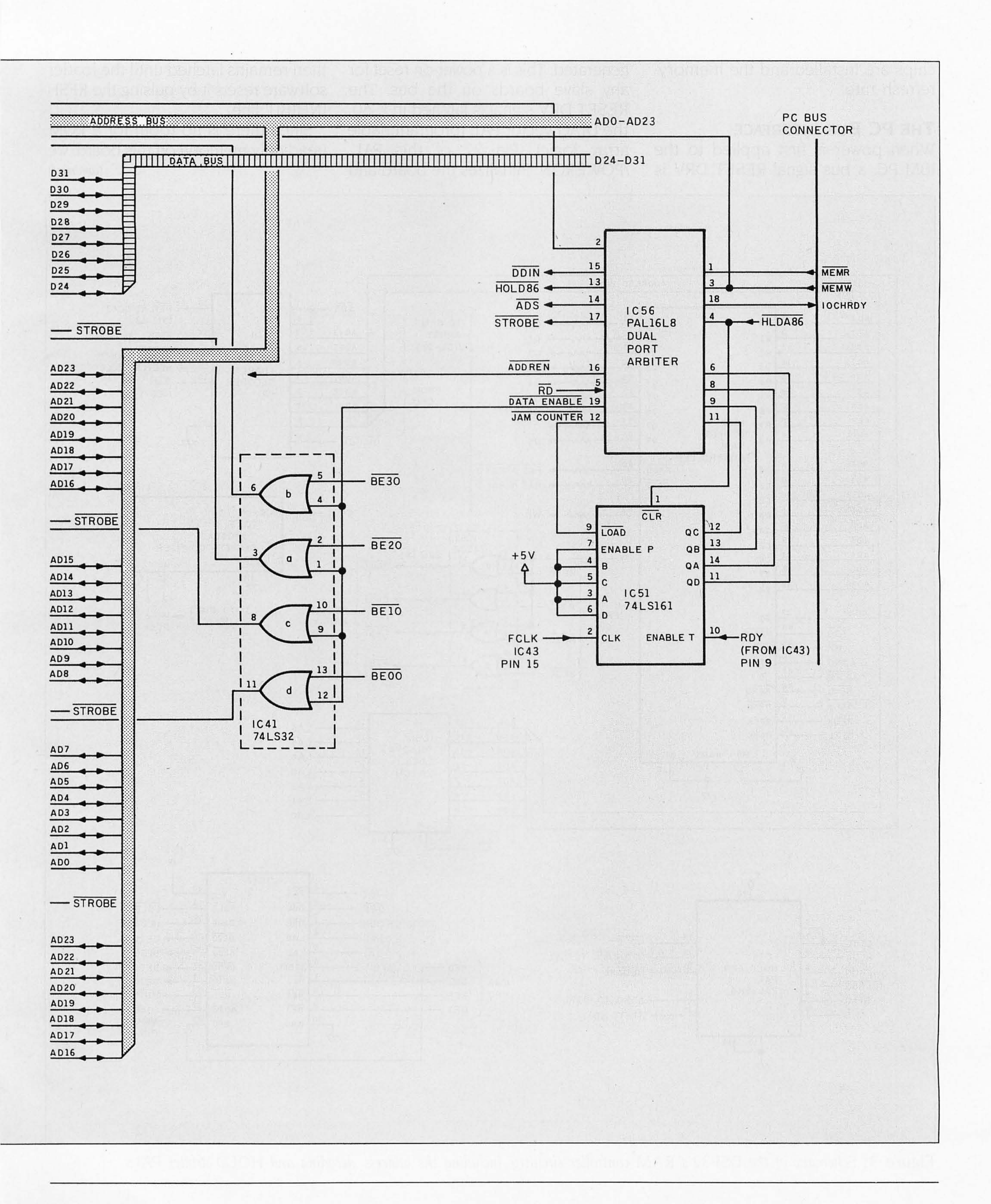


Figure 2: *Schematic of the* DSI-32's IBM PC *bus interface circuitry.*


ADDRESS BUS
AD0–AD23
DATA BUS
D24–D31
PC BUS CONNECTOR
D31
D30
D29
D28
D27
D26
D25
D24
STROBE
AD23
AD22
AD21
AD20
AD19
AD18
AD17
AD16
STROBE
AD15
AD14
AD13
AD12
AD11
AD10
AD9
AD8
STROBE
AD7
AD6
AD5
AD4
AD3
AD2
AD1
AD0
STROBE
AD23
AD22
AD21
AD20
AD19
AD18
AD17
AD16
DDIN
HOLD86
ADS
STROBE
ADDREN
RD
DATA ENABLE
JAM COUNTER
IC56
PAL16L8
DUAL
PORT
ARBITER
MEMR
MEMW
IOCHRDY
HLDA86
BE30
BE20
BE10
BE00
IC41
74LS32
CLR
LOAD
ENABLE P
B
C
A
D
CLK
ENABLE T
QC
QB
QA
QD
IC51
74LS161
+5V
FCLK
IC43
PIN 15
RDY
(FROM IC43)
PIN 9

chips are installed and the memory-refresh rate.

THE PC BUS INTERFACE

When power is first applied to the IBM PC, a bus signal RESET DRV is generated. This is a power-on reset for any slave boards on the bus. The RESET DRV signal is latched in IC60, the DIAG vector PAL (programmable array logic). Pin 22 of this PAL, /POWERON, initializes the board and then remains latched until the loader software resets it by pulsing the RFSH INHIBIT line.

Since there is no room for a ROM (read-only memory) on this board, we

(continued)

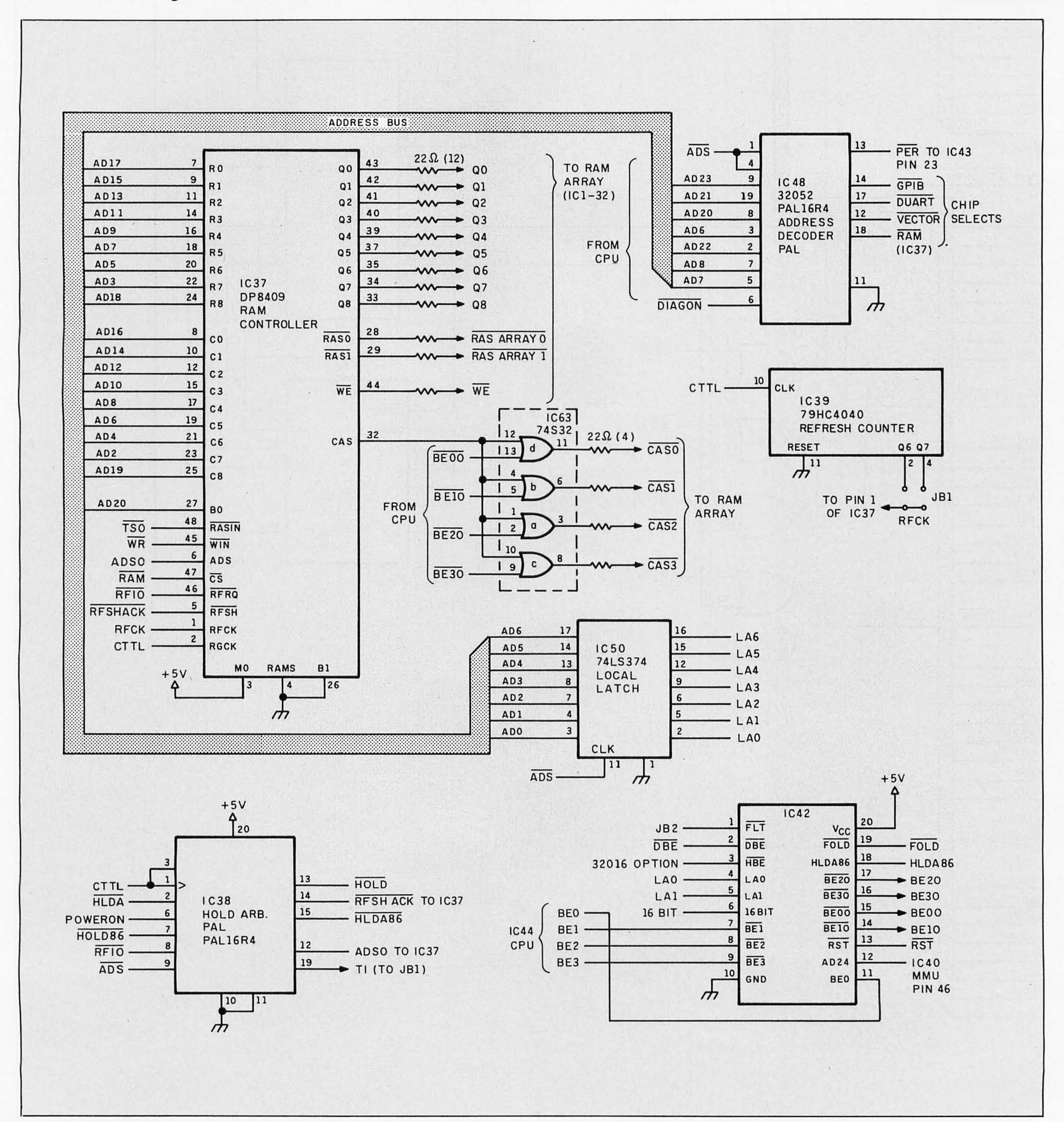


Figure 3: *Schematic of the DSI-32's RAM controller circuitry, including the address decoding and HOLD arbiter PALs.*



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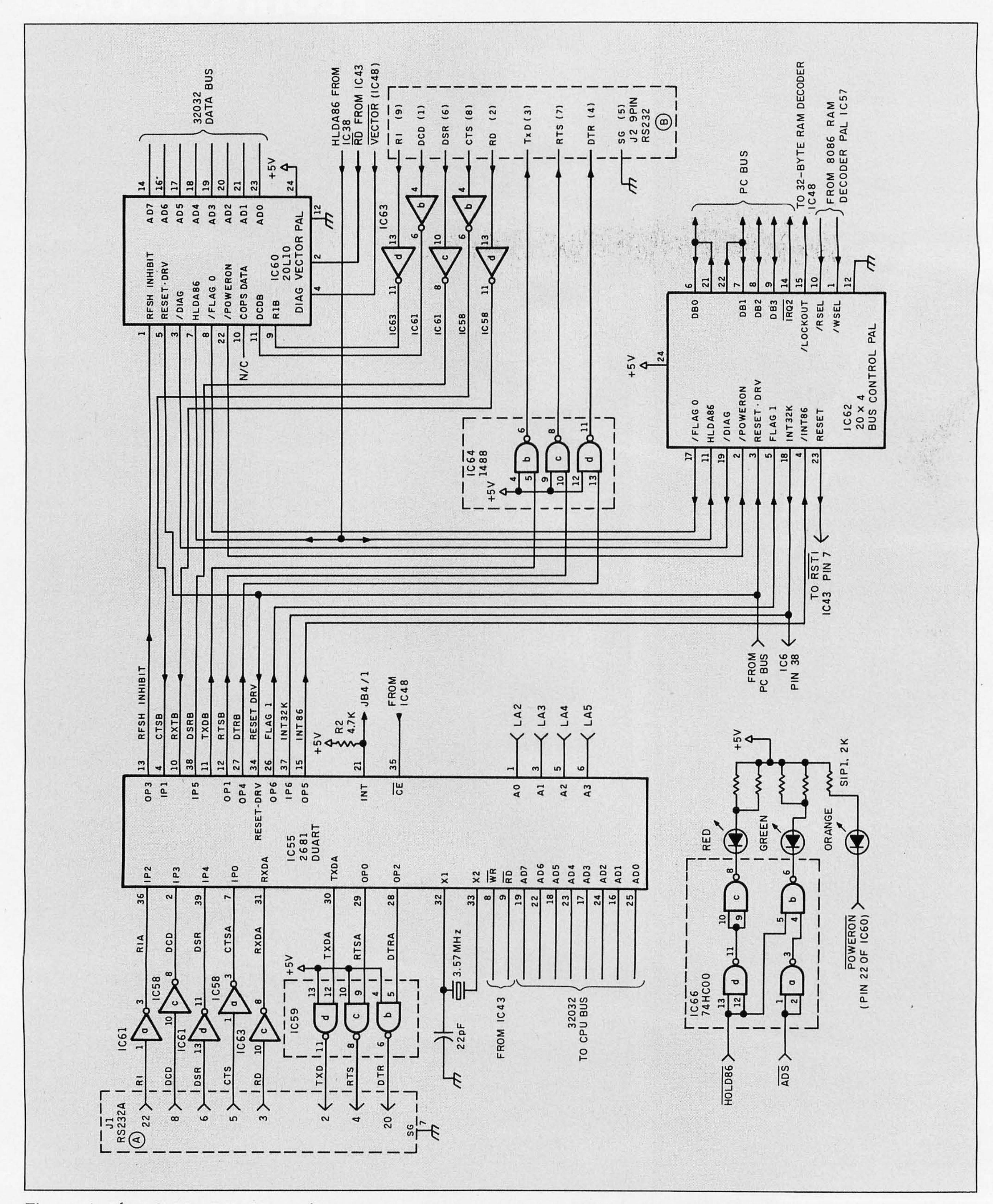
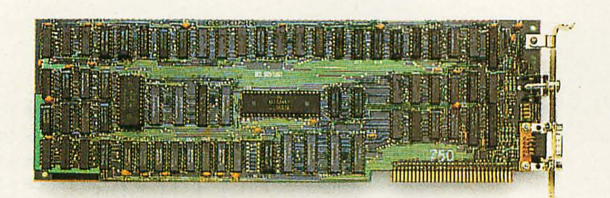
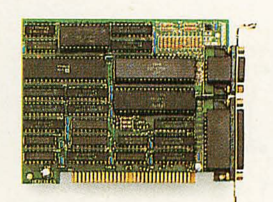


Figure 4: *The* DSI-32*'s* DUART *serial-port circuitry,* DIAG *vector* PAL, *and* IBM PC *bus control* PAL.

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needed some mechanism for the CPU to execute defined instructions during the power-on cycle. The DIAG vector PAL performs this function. The PAL forces a DIA instruction on the data bus whenever the CPU is uninitialized. This makes the CPU fetch a DIA as its first instruction (at address 0). [*Editor's note: All addresses to follow are in hexadecimal.*] The DIA instruction causes the CPU to flush its queue and execute a "branch to self." In this way, the 32032 is put into a very tight loop and won't lock up by executing some undefined instruction from its uninitialized main RAM memory space. The remaining function of the DIAG vector PAL is to act as a 4-bit read-only port so the CPU can read the RS-232C status lines of J2.

(continued)

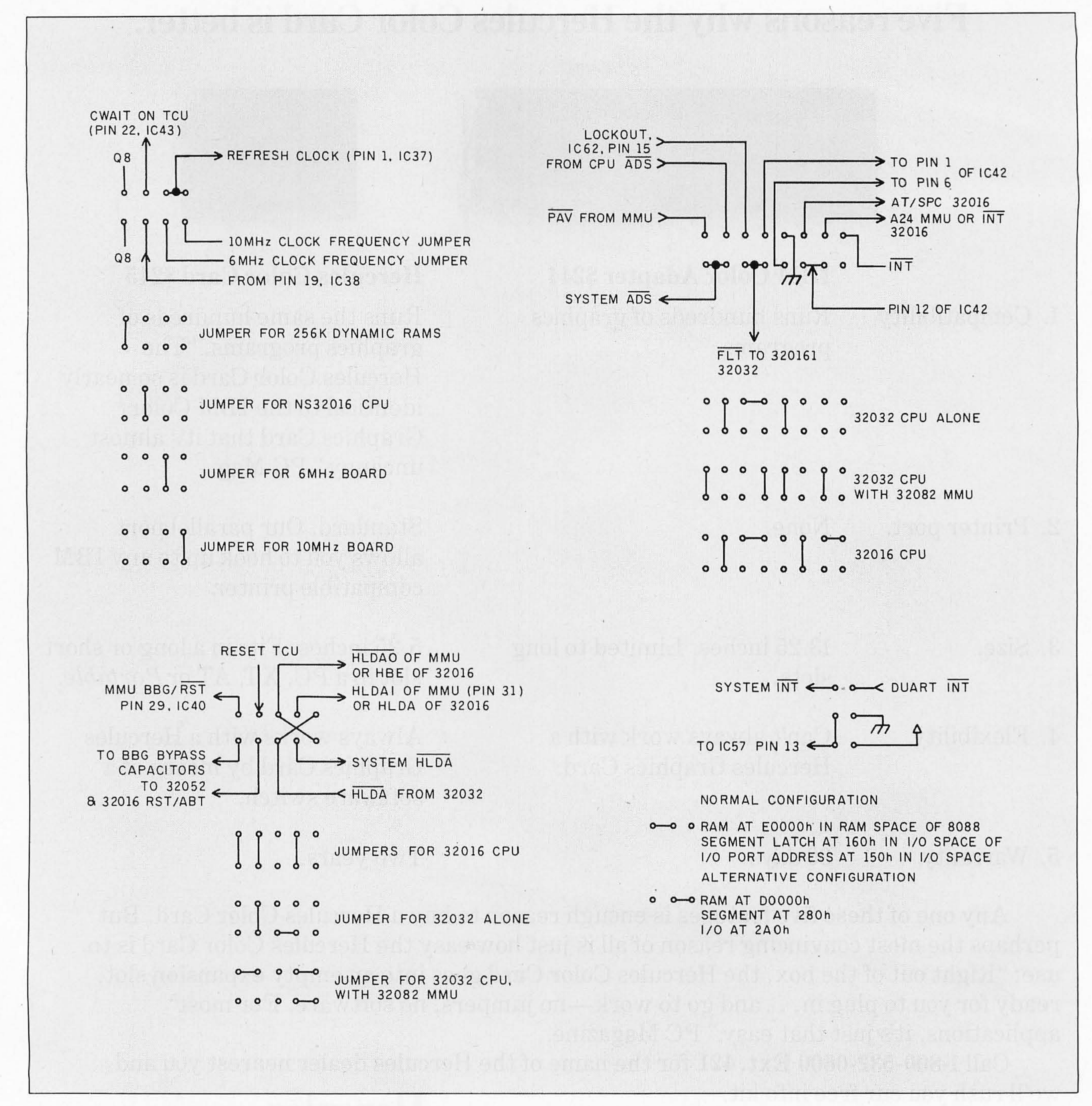
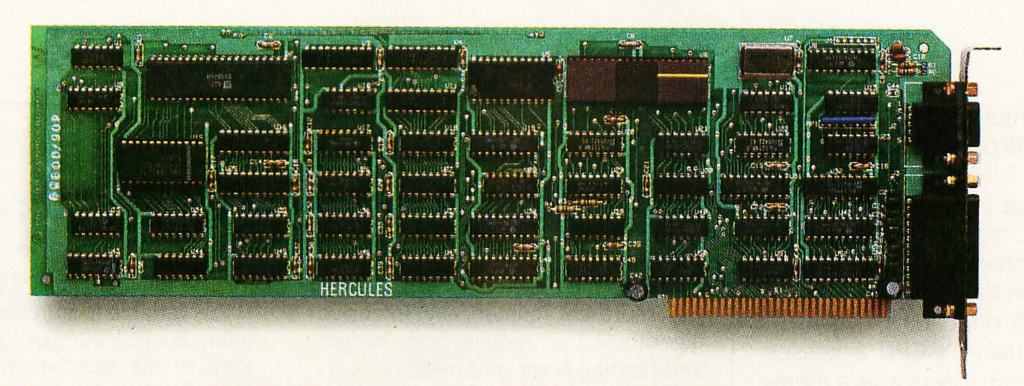


Figure 5: *Various jumper configurations for the DSI-32. All diagrams are shown looking at the top of the board, with the edge connector to the bottom right.*



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The PC bus interface PAL, IC62, performs many functions. It provides the IBM PC with a 2-bit status (read) port and also a 4-bit control (write) port. Also, this PAL supplies two polled flags for interprocessor communication, in addition to the one level of interrupt in each direction.

When the IBM PC's CPU accesses the DSI-32's RAM, it performs a memory (read or write) cycle in a 64K-byte segment of its address space. For the PC XT this is from E000 to EFFF. For the PC AT the board can be mapped from D000 to DFFF. IC47 determines which 64K-byte segment of the DSI-32 address space the PC is referencing.

When a memory read/write request from the 8088 is detected by the dual port RAM controller (IC56), it asserts a HOLD (DMA) request to the 32032 CPU. When it is able to service the HOLD request, the 32032 responds with a HLDA (hold acknowledge) signal and IC56 completes the DMA cycle. Due to the 8-byte instruction prefetch queue on the 32032, the internal CPU state machine continues to run even after it has relinquished its bus to the DMA cycle. This is fortunate because, although the much slower 8088 may take almost a microsecond to complete its portion of the DMA cycle, the usual loss of execution time to the 32032 is only 100 nanoseconds.

The default I/O (input/output) memory-address allocation for the DSI-32's control register can be changed if another board in your IBM PC has an address clash with the DSI-32. A program that comes with the kit guides your choice of memory and I/O port address configuration.

THE DYNAMIC RAM ARRAY

Either 256K bytes or 1 megabyte of dynamic RAM can be installed on the DSI-32. The first 14 megabytes of address space are uniquely decoded, allowing for future memory expansion on a separate board.

No parity checking or obvious-error correction was designed into the DSI-32. Parity checking on an IBM PC slave board is of little use. The only action you could take if an error were

BENCHMARKS

These three benchmarks in table A represent numerically intensive algorithms that require both integer and floating-point arithmetic.

The Sieve of Eratosthenes tests the performance of a high-level language implementing Boolean algebra and integer arithmetic (see listing A). The Float benchmark examines the processor's ability to execute floating-point array arithmetic (see listing B). The FLT benchmark tests the speed of the floating-point coprocessor (see listing C).

Array handling is primarily exercised by the Float and Sieve benchmarks, since the FLT benchmark uses only scalar calculations.

It should be noted, however, that the Sieve benchmark uses only a Boolean array, and this negates much of the throughput advantage of the NS32032's 32-bit bus (and indeed the VAX's 64-bit bus), tending to favor the 8- and 16-bit processors.

NOTES ON BENCHMARKS

The Sieve benchmarks that were run on the IBM PC XT and PC AT were written in Digital Research C. The FLT benchmark used Microsoft FORTRAN for the XT and DR F77 for the AT.

The variable *n* represents the maximum control number on the major loop of the benchmark test. In the Sieve benchmark, the major loop was run 10 times.

N/D indicates No Data, a test not run.

N/A indicates Not Available. No compiler could be found that could use arrays with more than 64,000 elements.

The five target machines being compared are the IBM PC XT (8088 CPU), the IBM PC AT (80286 CPU), the VAX-11/750, the VAX-11/780, and Definicon System's DSI-32 coprocessor (10-MHz 32032 CPU). All five machines have additional numeric-processing hardware:

1. IBM PC XT has Intel's 8087 floating-point chip (4.77 MHz).
2. IBM PC AT has Intel's 80287 floating-point chip (4.0 MHz).
3. VAX-11/750 has Digital Equipment's Floating-Point Accelerator.
4. VAX-11/780 has Digital Equipment's Floating-Point Accelerator.
5. DSI-32 coprocessor has National Semiconductor's 32081 FPU (floating-point unit).

The compilers used for the PC XT and PC AT were chosen on their pub-

Table A: *Execution time (in seconds) for 10 iterations of the Sieve. All machines have floating-point accelerators.*

Sieve Benchmark

n	IBM PC XT	IBM PC AT	VAX-11/750	VAX-11/780	DSI-32
8191	11.6	3.71	2.41	1.90	1.85
20000	35.3	8.13	6.11	3.04	4.52
30000	44.9	12.40	N/D	N/D	6.78
40000	351.5	99.71	13.13	6.38	9.04
80000	N/A	N/A	29.65	13.34	18.12

Float Benchmark

n	IBM PC XT	IBM PC AT	VAX-11/750	VAX-11/780	DSI-32
40000	11.46	17.71	0.83	0.50	0.84

FLT Benchmark

n	IBM PC XT	IBM PC AT	VAX-11/750	VAX-11/780	DSI-32
256000	119.3	134.0	9.48	6.18	16.48

lished reputation for generating high-speed code. Microsoft FORTRAN version 3.1 was used for the FLT and Float benchmarks on the PC XT. As it did not execute on the PC AT, Digital Research F77 was used for the FLT and Float benchmarks on that machine. Digital Research C was used for the Sieve benchmark on both the PC XT and the PC AT. The FORTRAN compiler for the VAX was written by Digital Equipment running under the VMS operating system.

The compilers for the DSI-32 coprocessor were written by Green Hills Software and ported to the Definicon MS-/PC-DOS environment.

Listing A: *The Sieve benchmark.*

```
#define LIMIT 8191
#define ITS 10
#define FALSE 0
#define TRUE 1
main ()
{
char flags[LIMIT + 1];
    register long i,prime,k;
    int count,iter;
        for (iter = 1;iter< = ITS;iter + + ) {
            count = 0;
            for (i = 0;i< = LIMIT;i + + ) flags[i] = TRUE;
            for (i = 0;i< = LIMIT;i + + ) {
                if (flags[i]) {
                    prime = i + i + 3;
                    for (k = i + prime;k< = LIMIT;k + = prime) flags[k] = FALSE;
                    count + + ;
                }
            }
        }
    printf("Found %d primes",count);
}
```

Listing B: *The Float benchmark.*

```
      PROGRAM FLOAT
      DIMENSION RARRAY (40000)
      COMMON /FAST/ RARRAY
      INTERGER*4 I
      DO 10 I = 1,40000
10    RARRAY(I) = 1.0
      DO 91 I = 1,40000
      RARRAY(I) = RARRAY(I) *
    C RARRAY(40000 - I)
91    CONTINUE
      STOP
      END
```

Listing C: *The FLT benchmark.*

```
      C
      PROGRAM FLT
      INTEGER*4 I,J
      REAL*8 X,Y,Z
      DO 10 I = 1,256000
      J = 256000 - I
      X = FLOAT(I)
      Y = FLOAT(J)
      Z = Y/X
      X = Y - Z
      Y = Z*X
      Z = Y + X
10    CONTINUE
C Force the loop optimizer to retain
C all four lines by:
      X = Z + Y
      STOP
      END
```

detected would be to shut down the host 8088 CPU. Although the 8088 then reports the address currently on its bus, this usually bears no relation to the true cause of the problem. Conventional external error correction is slow and requires adding wait states to the memory cycles, reducing the 32032's performance.

There is a level of protection provided by the DSI-32 interface software. Should the 32032 execute an instruction that it cannot decode (such as would occur on a faulty program read), it executes an ILLEGAL INSTRUCTION trap. This trap is caught by the Definicon MS-/PC-DOS interface software, and the full status is reported to the operator.

To further increase the board's reliability, a REFRESH INHIBIT control signal has been made available to the 8088/8086 CPU. This lets the diagnostic software determine the exact safety margin of each dynamic RAM chip in the memory array. This signal is also used to start the CPU after a cold boot.

Nevertheless, true error correction is available as an option on the 1-megabyte advanced kit. The DSI-32 is designed to accommodate the new INMOS (a British semiconductor company) 256K by 1-bit RAM chip that internally detects and corrects errors, such as those occurring from irregular refresh or alpha-particle activity.

The RAM array is driven and controlled by a National Semiconductor DP8409. This device (IC37) contains high-current outputs that can drive the highly capacitive RAM array, as well as circuitry to insert "hidden" refresh cycles whenever the RAM is inactive. These cycles allow the CPU to avoid the otherwise mandatory HOLD request (every 12 microseconds or so) to allow the DP8409 to refresh the array. Nevertheless, when a forced refresh is required, it is completed in two T (timing) states, leaving the processor's execution essentially unaffected.

Since both the RAM array and the 8088/8086 are asynchronously placing HOLD requests on the CPU, a

(continued)

DSI-32 HARDWARE, SOFTWARE, AND SUPPORT

The following hardware kits and software are available from Definicon Systems Inc., 21042 Vintage St., Chatsworth, CA 91311, (818) 341-5654.

HARDWARE

1. Starter kit — 32032 CPU and 32081 FPU, 6-MHz clock rate, 256K bytes of RAM (32 64K by 1-bit chips) wave-soldered, partially tested, fully socketed printed-circuit board. Full set of integrated circuits and assembly instructions. Diagnostic software disk. Simplified NSX-compatible assembler/linker/loader. MS-DOS interface software, advanced debug monitor. Public-domain software disk (supplied upon request). Price: $995.
2. Advanced kit — Same as above, except CPU and FPU are 10-MHz and 1 megabyte of memory (32 256K by 1-bit chips) is supplied. Price: $1495.

The DSI-32 is suitable for use with the IBM PC or any identical "clone" microcomputer. However, a money-back guarantee is the only guarantee of compatibility offered by Definicon. The DSI-32 draws up to 15 watts from the PC's power supply. Make sure you have that much spare power before ordering.

A fixed disk is almost essential if you are to run the Green Hills compilers (which range to 250K bytes of code).

SOFTWARE

Public-domain compilers/interpreters are available for FORTH, Small-C, Pascal, and Tiny BASIC. A disk containing them will be included with your kit provided that you specifically ask for it.

The following advanced software is available. (Note that the C and Pascal compilers will run in 256K bytes of RAM, but their capabilities will be considerably limited. The FORTRAN compiler will not run in 256K bytes of RAM. If you want to run these compilers, Definicon suggests you use the Advanced kit with its 1-megabyte of RAM.)

1. Green Hills C Compiler: Kernighan and Ritchie C plus full Berkeley 4.2 UNIX extensions.
2. Green Hills Pascal Compiler: Full Berkeley 4.2 UNIX-compatible plus many extensions.
3. Green Hills FORTRAN Compiler: ANSI (American National Standards Institute) FORTRAN 77 plus full Berkeley 4.2 UNIX extensions.
4. Definicon/Computer Systems Design NS32000 Assembler/Linker: Advanced National Semiconductor NSX syntax assembler with the GENIX extensions required by Green Hills compilers. Supports fully relocatable code and "Pascal-like" high-level constructs. Linker supports assembler output syntax and fully relocatable code, including named COMMON blocks and initialized statics.
5. Definicon/Computer Systems Design NS32000 Library Manager and Programmer's Utilities: LIB32 program to form and examine libraries of object modules, assembly and high-level language examples for direct (OEM) interface to the Definicon MS-/PC-DOS interface.

Prices:

Library manager/programmer's utilities:	$49
Assembler/linker (purchased separately):	$149
One compiler (your choice), including assembler/linker:	$299
Two compilers, including assembler/linker (one purchase):	$499
Three compilers, including assembler/linker (one purchase):	$649
Any compiler, purchased alone (needs assembler above):	$249

Note: Green Hills Software has helped make these compilers available to BYTE readers using the Definicon MS-/PC-DOS software environment at prices well below those of the identical compilers for their original UNIX environment.

A 32-bit FORTH interpreter is available for $299 from Symbolic Processing Systems, 501 West Maple, Orange, CA 92668, (714) 637-4298. This FORTH includes a screen editor, string and file handling, and full floating-point support. Debugging aids—including TRACE and VIEW—are provided. The metacompiler and source-code screens are provided to ease system customization.

SUPPORT

The prices Definicon is charging for the software are special discounts for BYTE readers. The only support that Definicon can offer to purchasers of this software is a guarantee to respond promptly to written bug reports. Definicon assumes that BYTE readers will be proficient in the basic programming syntax of a language before they order these products, and the documentation provided reflects this assumption.

Trevor Marshall's Thousand Oaks Technical Database (RCP/M) will act as a focal point for public-domain software for the DSI-32. The database may be reached on the public access number (24 hours a day, 1200 bits per second) at (805) 492-5472, or, for uploads, at the restricted (sysop's) number, (805) 493-1495.

Micro Cornucopia (POB 223, Bend, OR 97709, (503) 382-8048) has agreed to form a users group to support the DSI-32. Contact them directly for details.

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In conjunction with the interrupt-driven 16-bit timer and the two serial ports, an MMU will let the DSI-32 run UNIX.

HOLD arbiter PAL (IC38) allots each a priority and ensures that no access contention can occur.

Unusual Components in This Design

Murata ceramic resonators are used instead of quartz crystals. Although not quite as stable as the crystals, they are perfectly adequate. The typical frequency tolerance is ±0.5 percent maximum. They are easier to mount than crystals and are also cheaper. Note that the RS-232C data-transfer rate can be up to 3 percent slower due to the use of a standard 3.58-MHz resonator rather than the 3.686-MHz resonator originally specified for the 2681 DUART.

Rogers Q-PAC bypass capacitors are used in several critical areas of the board. They provide near-perfect bypassing of high-frequency transients and help reduce noise that otherwise might reduce reliability.

Optional 32082 Memory-Management Unit

The DSI-32 can accommodate the NS32082 MMU. This, in conjunction with the interrupt-driven 16-bit timer and the two serial ports, gives it the capability of running UNIX (when it becomes available). The MMU also adds some debugging capability to the current monitor, such as a breakpoint-on-address reference.

A Brief Look at Software

In addition to a number of public-domain compilers and interpreters, three high-performance, UNIX-compatible, optimizing compilers for the DSI-32 are currently available from Definicon. The Green Hills Software C, FORTRAN, and Pascal implement the full Berkeley 4.2 extensions in addition to the commonly accepted language definitions. These compilers produce NS32032 source code, which is assembled with the Computer Systems Design/Definicon assembler, linker, and loader. In addition, a 32-bit FORTH interpreter, a Tiny BASIC, and a dBASE II compiler were scheduled for release last month.

The disk operating system is MS-/PC-DOS. No special partitions or file conversions are required. The 32032 data files can be identical to their MS-/PC-DOS counterparts, and 32032 executable code files exist on disk as standard MS-/PC-DOS files. Software development is done entirely within the MS-/PC-DOS command shell, with no need for special editors or other file managers.

A resident (RAM-based) monitor allows easy debugging. Its command syntax is similar to DEBUG and DDT (dynamic debugging tool). It allows single-step execution, running with multiple breakpoints, and, with the optional MMU, breakpoint-on-address reference. Also, the monitor includes standard memory and register display and substitute features. A powerful disassembler with full floating-point support is part of the monitor.

Next Month

We have taken a glimpse inside the hardware of the DSI-32, and we hope that this gives you some idea of this coprocessor board's speed and flexibility. Although we have discussed software only briefly, next month we will look in greater detail at the languages and programming tools available. ■

ACKNOWLEDGMENT

The authors are indebted to Martin A. Lewis of Cambrian Consultants Inc. of Calabasas, California, for his help and guidance during the project and to applications engineer Les Wilson of National Semiconductor for his untiring assistance.

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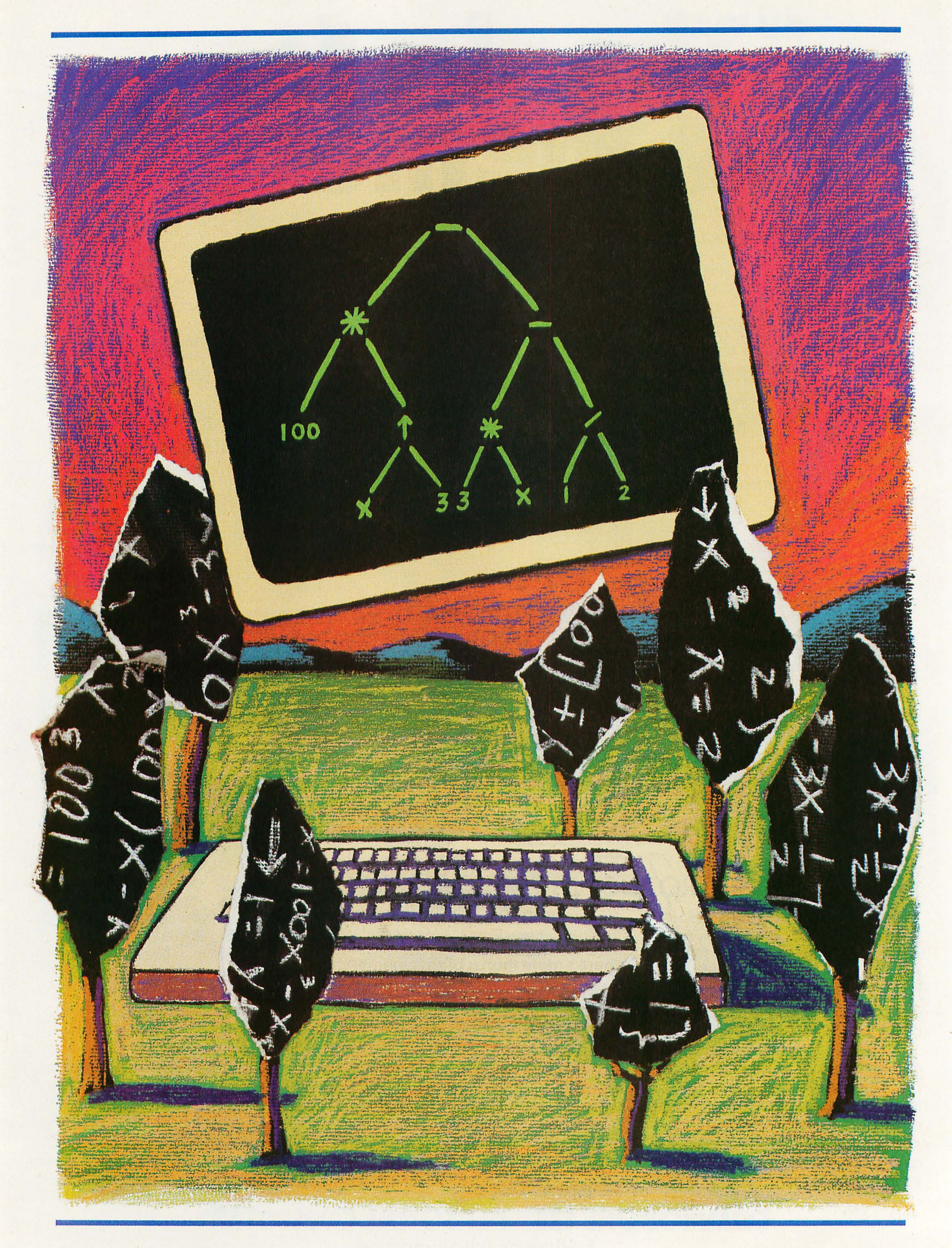
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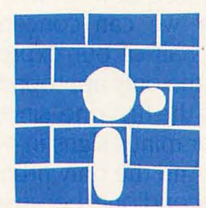


ILLUSTRATED BY JAMIE HOGAN

Context-Free Parsing of Arithmetic Expressions

BY JONATHAN AMSTERDAM

Parse integer arithmetic expressions into executable form



I think I was in the fifth grade when I first heard about My Dear Aunt Sally. The teacher had no sooner written "3 + 4 × 5" on the blackboard than I, impetuous young fool that I was, shouted out "35!" After pointing out that the correct answer was 23, the teacher introduced me to my new-found relative—My Dear Aunt Sally: multiplication, division, addition, subtraction. That's the order in which we calculate arithmetic expressions. Once we learn it, it's an easy rule to master.

But computers are not so clever. They find these so-called operator precedence rules a bit of a nuisance. Some programmers, like the folks at Hewlett-Packard and FORTH inventor Charles Moore, have taken an easy way out by using Polish-postfix (or reverse-Polish) notation, in which 3 + 4 * 5 becomes 3 4 5 * +.

This notation is easy for computers to understand and, FORTH addicts will swear, for people too. But those of us who prefer to keep our eyes uncrossed would like some way to teach the machine our way of doing business.

What we want, more precisely, is a way to *parse* ordinary integer arithmetic expressions—that is, to translate the string of symbols that make up such an expression into something with more structure, something that captures the fact that 4 * 5 is a meaningful component of 3 + 4 * 5, while 3 + 4 is not. We can break the problem into two parts: writing a set of rules that correctly describes the structure of the expressions, and implementing those rules in a computer program. The result will be a parsing algorithm that, when combined with a simple evaluation function, gives a four-function integer calculator of the "algebraic," or more commonly, Texas Instruments variety. I'll discuss more general applications of parsing at the end of this article.

Context-Free Grammars

First, though, I need to describe the structure of arithmetic expressions. Here I'll use an idea originally developed by linguists. At one time, they thought that the syntax of English and other natural languages could be described by a series of rules like the following:

```
S -> NP VP
NP -> ADJ N
VP -> V ADV
```

(continued)

Jonathan Amsterdam is a graduate student at the Massachusetts Institute of Technology Artificial Intelligence Laboratory. He can be reached at 1643 Cambridge St. #34, Cambridge, MA 02138.

These rules say that a sentence consists of a noun part and a verb part, a noun part consists of an adjective followed by a noun, and a verb part consists of a verb followed by an adverb. We can use these rules to generate a subset of English by starting with the "S" rule and replacing symbols on the right-hand side with the corresponding rule. The rules I've given don't allow much freedom. You can replace the NP of the first rule with ADJ N and the VP with V ADV, giving you sentences of the form adjective-noun-verb-adverb: sentences like "Loose lips sink fast" (but *not* "Loose lips sink ships"). If you use more rules, you can capture more of English, but Noam Chomsky (considered the founder of transformational or generative grammar) showed in the late 1950s that these *context-free* grammars—so called because the symbols on the left-hand sides of the right arrows don't have to appear in any special context in order to be substituted into right-hand sides—aren't powerful enough to describe any natural languages.

They're just the ticket, though, for computer languages. Most of the syntax of modern programming languages is describable by context-free grammars, including that small part of syntax we're interested in here. In table 1, I present the context-free grammar for arithmetic expressions in Backus-Naur form.

I've switched syntax from the linguists' to the computer scientists'. The ::= is just like the right arrow, and the | means "or." These rules say that an expression is a term, a term plus an expression, or a term minus an expression; a term is a factor, a factor times a term, or a factor divided by a term; and a factor is either a number, a minus sign followed by a factor, or an expression enclosed in parentheses. These rules capture the correct precedence rules for the four common arithmetic operations, as well as unary minus and parentheses (both of which have higher precedence than any other operator).

If you look carefully at the rules, you may find yourself getting dizzy. It seems that each rule is defined in terms of itself and another rule. Where does it all end? It ends in the characters that make up the four operations and parentheses and in the numbers. Let's use the rules to parse 3 + 4 * 5. The description of what we're doing is called a "parse tree."

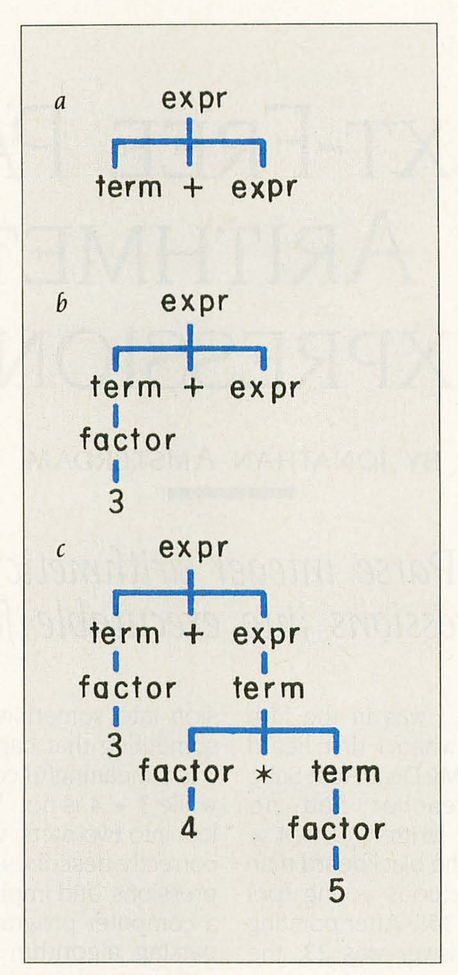


Figure 1: *The steps in creating the parse tree for 3 + 4 * 5.*

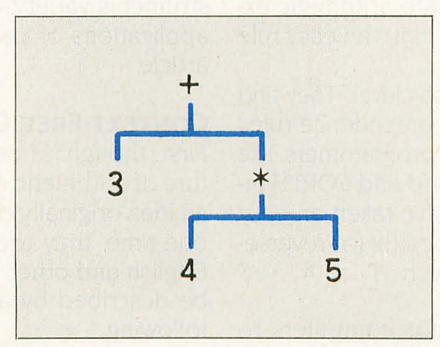


Figure 2: *An abbreviated parse tree of 3 + 4 * 5.*

Parsing an Expression

To begin with, the whole thing is an expression (we always start parsing with expr). Now, there are three kinds of expressions: one is just a term, another is two things separated by a plus sign, and the third is two things separated by a minus sign. With 3 + 4 * 5, we obviously have two things that are separated by a plus sign. So far, the parse tree looks like figure 1a. Let's concentrate next on the first component, which is the number 3. We know it's a term, but which of the three term rules apply? Again, the only choice is the first one, which says a term is a factor. And now we have reached dry land because a factor is, among other things, a number. Our parse tree now looks like figure 1b.

Now we can concentrate on the other half of our expression, 4 * 5. Here, the only appropriate expression rule is the first one, since there are no plus or minus signs in our subexpression. And the only fitting term rule is the second one, because of the multiplication sign. The complete parse tree is shown in figure 1c.

Do you see how the parse tree captures the precedence rules? Notice that the 4 * 5 is together on a single subtree, joined to the 3 by the plus sign. If you eliminate all the occurrences of expr, term, and factor, which were useful in the parsing process but now serve no purpose, you have the much simpler tree shown in figure 2.

It is just these latter trees that my parsing program will construct. Once you've got the tree, it's easy to actually calculate the expression: Just start at the root (top) of the tree, evaluate (recursively) the left and right subtrees, and then perform the operation at the root on the two results.

From Grammar to Parser

But how do you go from the three grammar rules I described earlier to a working program? The choice of which rule to apply at any step seems to require looking ahead. When con-

fronted with 3 + 4 * 5, I chose the second expr rule because of the plus sign. This required only slight look-ahead, but consider the expression 3 * 4 * 5 * 6 + 7. This is also correctly described by the second expr rule, but now the look-ahead is considerably larger, and I could make it as large as I want by putting more multiplications before the addition. Now, an arithmetic expression 20 pages long may be absurd, but a program 20 pages long is not, so if you want to be able to generalize this technique to parsing programs, you have to confine the look-ahead. And even if you decide to take the easy way out by reading the whole input in at once and looking ahead, it would be inefficient to rescan the entire string over and over again.

In fact, there is a better way—the grammar rules require *no more than one character look-ahead*. How is this possible, after what I just said about choosing the right rule? If you examine the rules again, you'll notice that *an expression always starts with a* term. Sometimes the term is followed by a plus sign, sometimes a minus sign, sometimes nothing—but you can worry about that *after* parsing the term. Then you can peek at the next character to see if it's what you want, and if it's not, you can put it back. The "put-back" operation is easy to implement because you'll never have to put back more than one character. If you look at the rules for term and factor, you'll see that there, too, the correct rule can be chosen on the basis of only one character.

The construction of the actual program will be quite straightforward if you implement the parser by associating a procedure with each group of rules—one for the expr rules, one for the term, and one for the factor. The procedures just mirror the rules. Each procedure is responsible for parsing its own category of subexpression, consuming just enough of the input to do so, and returning the proper parse tree. For example, the expr procedure first calls the term procedure to take care of the parsing of the term; then it looks ahead to see if the next

(continued)

Table 1: *The grammar of arithmetic in Backus-Naur form.*

```
expr ::= term | term + expr | term - expr
term ::= factor | factor * term | factor / term
factor ::= number | -factor | (expr)
```

Listing 1: A *program to parse and evaluate ordinary integer arithmetic expressions.*

```
(* This is a Texas Instruments-style calculator. It parses arithmetic
   expressions using the usual precedence rules.
   Written by Jonathan Amsterdam, December 1984.
*)

PROGRAM TICalc;

CONST
  endOfFile = 0;      (* special character signifying end of file *)
  empty     = 127;    (* character used to indicate that savedChar is empty*)
  endOfLine = 13;     (* special character signifying end of line *)

TYPE
  nodetype = (binop, unop, number);
  node = ^noderec;
  noderec = RECORD
            CASE tag:nodetype OF
              binop: (operator: CHAR;
                      leftOperand, rightOperand:node);
              unop: (uOperator:CHAR;
                     operand:node);
              number:(num:INTEGER);
          END;

VAR
  savedChar: CHAR;
  digits: SET OF CHAR;

(* input functions *)

FUNCTION getChar:CHAR;
(* Useful low-level character input. Returns special characters at
   end of file and end of line. *)
VAR c:CHAR;
BEGIN
  IF savedCHAR <> chr(empty) THEN BEGIN
    getCHAR := savedChar:
    savedChar := chr(empty);
  END ELSE IF EOF THEN
    getChar := chr(endOfFile)
  ELSE IF EOLN THEN BEGIN
    getChar := chr(endOfLine);
    readln;
  END ELSE BEGIN
    read(c);
    getChar := c;
  END;
END;
```

(continued)

PROGRAMMING PROJECT

```
PROCEDURE ungetChar(c:CHAR);
(* Allows one character at a time to be pushed back on the input. *)
BEGIN
  IF savedChar = chr(empty) THEN
    savedChar := c
  ELSE
    writeln('ungetChar' can't unget more than one character at a time');
END;

FUNCTION nextChar:CHAR;
(* Skips over blanks. *)
VAR c:CHAR;
BEGIN
  REPEAT
    c := getChar
  UNTIL c <> ' '
  nextChar := c;
END;

FUNCTION charToInt(c:CHAR):INTEGER;
(* Converts a numeric character to an integer. *)
BEGIN
  IF NOT (c IN digits) THEN BEGIN
   writeln('charToInt: ', c, 'is not a digit');
   charToInt := 0;
  END ELSE
   charToInt := ord(c) - ord('0');
END;

FUNCTION getNum(c:CHAR):INTEGER;
(* Reads a number from the input. The first digit of the number has
   already been read and is passed as an argument. *
VAR n:INTEGER;
BEGIN
   n := 0;
   REPEAT
     n := 10*n + charToInt(c);
     C := getChar;
   UNTIL NOT (c IN digits);
   ungetChar(c);
   getNum := n;
END;

(* node creation functions *)
(* The following three functions create nodes for the parse tree. The first
   two each return NIL if their node arguments are NIL. *)

FUNCTION binopNode(opor:CHAR; lopand, ropand:node):node;
VAR n: node;
BEGIN
  IF (lopand = NIL) OR (ropand = NIL) THEN
    binopNode := NIL
  ELSE BEGIN
    New(n, binop);
    WITH n^ DO BEGIN
      tag := binop;
      operator := opor;
      leftOperand := lopand;
      rightOperand := ropand;
    END;
    binopNode := n;
  END;
END;
```

```
FUNCTION unopNode(opor:CHAR; opand:node):node;
VAR n:node;
BEGIN
  IF opand = NIL THEN
    unopNode := NIL
  ELSE BEGIN
    new(n, unop);
    WITH n^DO BEGIN
      tag := unop;
      uOperator := opor;
      operand := opand;
    end;
    unopNode := n;
  END;
END;

FUNCTION numberNode(i:INTEGER):node;
VAR n:node;
BEGIN
  new(n, number);
  WITH n^ DO BEGIN
    tag := number;
    num := i;
  END;
  numberNode := n;
END;

(* tree-printing procedures *)

PROCEDURE ptree(n:node; depth:INTEGER);
BEGIN
  WITH n^ DO
    CASE tag OF
      binop: BEGIN
                  ptree(leftOperand, depth+2);
                  writeln(' ':depth,operator);
                  ptree(rightOperand, depth+2);
             END;
      unop: Begin
                  writeln(' ':depth,uoperator);
                  ptree(operand, depth+2);
             END;
      number: writeln(' ':depth,num);
    END;
END;


PROCEDURE PrintTree(n:node);
BEGIN
  ptree(n, 0);
END;

(* parser *)
(* Each of the three parsing functions returns NIL if an error occurs in the parse. *)
```

(continued)

One of the variants is for binary operations, another for unary operations, and a third for numbers.

nonblank character is a plus or minus and, if so, calls itself—recursively—to parse the rest of the expression. Finally, it combines the parse tree produced by term and the one produced by the recursive call on itself into a larger tree with the operator—plus or minus—at its root and returns this tree. The implementations of term and factor are similar.

IMPLEMENTATION

At this point, the actual programming is trivial; its outcome can be found in listing 1 and may be downloaded from BYTEnet Listings. (The phone number is (617) 861-9774.) I wrote it in UCSD Pascal on an Apple II, but I didn't use any features peculiar to that implementation, so it should be portable. The nodes of the parse tree are represented by variant records. One of the variants is for binary operations like addition and multiplication, another for unary operations like negation, and a third for numbers (I used integers to keep it simple).

Because I have to put back a character on the input sometimes, I built an input procedure on top of Pascal's; this is a good idea anyway, because Pascal has such hideous I/O (input/output). My routine, called getChar, always returns a character, even at end of line or end of file; two special characters are chosen for these cases. The getChar routine interacts with ungetChar through the variable savedChar to allow one character to be put back on the input. The nextChar function ignores blanks, which is usually the right thing to do. The getNum function translates a string of

(continued)

```
FUNCTION term:node; FORWARD;

FUNCTION factor:node; FORWARD;

FUNCTION expr:node;
(* An expression is either a term, or a term +,- an expression. *)
VAR c:CHAR;
  n:node;
BEGIN
  n := term;
  expr := n;
  IF n <> NIL THEN BEGIN
    c := nextChar;
    IF (c = '+') OR (c = '-') THEN
      expr := binopNode(c, n, expr)
    ELSE IF c <> chr(endOfLine) THEN
      ungetChar(c);
  END;
END;


FUNCTION term(*:node*);
(* A term is either a factor, or a factor *,/ a term. *)
VAR c:CHAR;
    n:node;
BEGIN
  n := factor;
  term := n;
  IF n <> NIL THEN BEGIN
    C := nextChar;
    IF (c = '*') OR (c = '/') THEN
      term := binopNode(c, n, term)
    ELSE
      ungetChar(c);
    END;
END;

FUNCTION factor(*:node*);
(* A factor is either a number, or a - followed by a factor, or a parenthesized
   expression. *)
VAR c:CHAR;
BEGIN
  c := nextChar;
  IF c IN digits THEN
    factor := numberNode(getNum(c))
  ELSE IF c = '-' THEN
    factor := unopNode(c, factor)
  ELSE IF c = '(' THEN BEGIN
    factor := expr;
    IF nextChar <> ')' THEN
      writeln('close parenthesis expected');
  END ELSE BEGIN
    writeln('illegal expression');
    factor := NIL;
  END;
END;
```

```
FUNCTION eval(n:node):REAL;
(* Evaluates a parse tree. Assumes that the only binary operations are +, -, *,
and / and that the only unary operation is -. *)
VAR op1, op2:REAL;
BEGIN
  WITH n^ DO
    CASE tag OF
      binop:
        BEGIN
          op1 := eval(leftOperand);
          op2 := eval(rightOperand);
          CASE operator OF
            '+': eval := op1 + op2;
            '-': eval := op1 - op2;
            '*': eval := op1 * op2;
            '/': eval := op1 / op2;
          END;
        END;
      unop: eval := -eval(operand);
      number: eval := num;
    END;
END;

PROCEDURE run;
VAR n:node;
    c:CHAR;
BEGIN
  REPEAT
    write('> ');
    n := expr;
    IF n <> NIL THEN BEGIN
      writeln;
      printTree(n);
      writeln;
      writeln(eval(n):0:2);
    END;
  UNTIL FALSE;
END;

BEGIN (*** MAIN PROGRAM ***)
  writeln('TI-style calculator');
  writeln('Enter an arithmetic expression and hit <RETURN>.');
  writeln('I will print a parse tree and evaluate the expression.');
  digits := ['0'..'9'];
  run;
END.
```

digits into an integer; I couldn't use Pascal's read procedure because I don't know I have a number until I've read the first digit.

The three parsing functions, expr, term, and factor, each return the parse tree they construct or NIL if an error occurred during the parse. If the parse is successful, the completed parse tree is fed to the evaluation function eval, and the answer appears. Just for fun, I wrote a simple procedure (printTree in listing 1) to print out the parse tree. The tree comes out sideways, but what do you expect for 10 lines of code?

Where to Go from Here

As I said at the beginning of this article, this little calculator's just the tip of the iceberg. You might begin with some simple modifications, like disposing of the storage used by the parse tree when it is no longer needed, improving the error checking in both the parsing and evaluation phases, and making it simpler to exit the program. The calculator could easily be extended to handle floating-point numbers and other operations (such as exponentiation and square root).

It would be somewhat more challenging to make the operators left associative. That is, now the expression "3 + 4 + 5" is parsed as if it were "3 + (4 + 5)," but it really ought to be parsed as "(3 + 4) + 5." Simply rewriting the grammar rules won't work; you have to modify the parser directly.

The calculator could be made much more powerful by adding a "memory" in the form of 26 one-letter variables, *a* through *z*, and a new grammar rule:

assignment ::= letter := expr

(Note that the ::= is part of the description of the rule, while the := is actually part of the rule's right-hand side.) The meaning of this rule is "assign the value of the expression to the variable." To make this work, variables have to be able to appear in expressions, so a rule should be added that says that a single letter can be a factor.

Is it starting to look like a programming language? Here are two more useful rules:

if_stmt ::= if bool_expr then stmt else stmt
while_stmt ::= while bool_expr do stmt

I leave the rules for Boolean expressions and statements to you. Once you've built up the parse tree for a program in this simple programming language, you have two choices: You can *interpret* the parse tree right then and there, as I did above, or you can *compile* it by outputting instructions (in machine language or in another high-level language) for carrying out the statements of the program. ■

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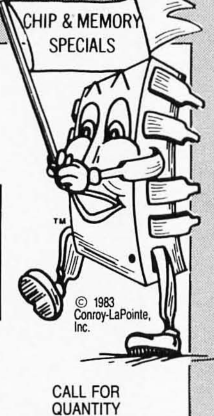
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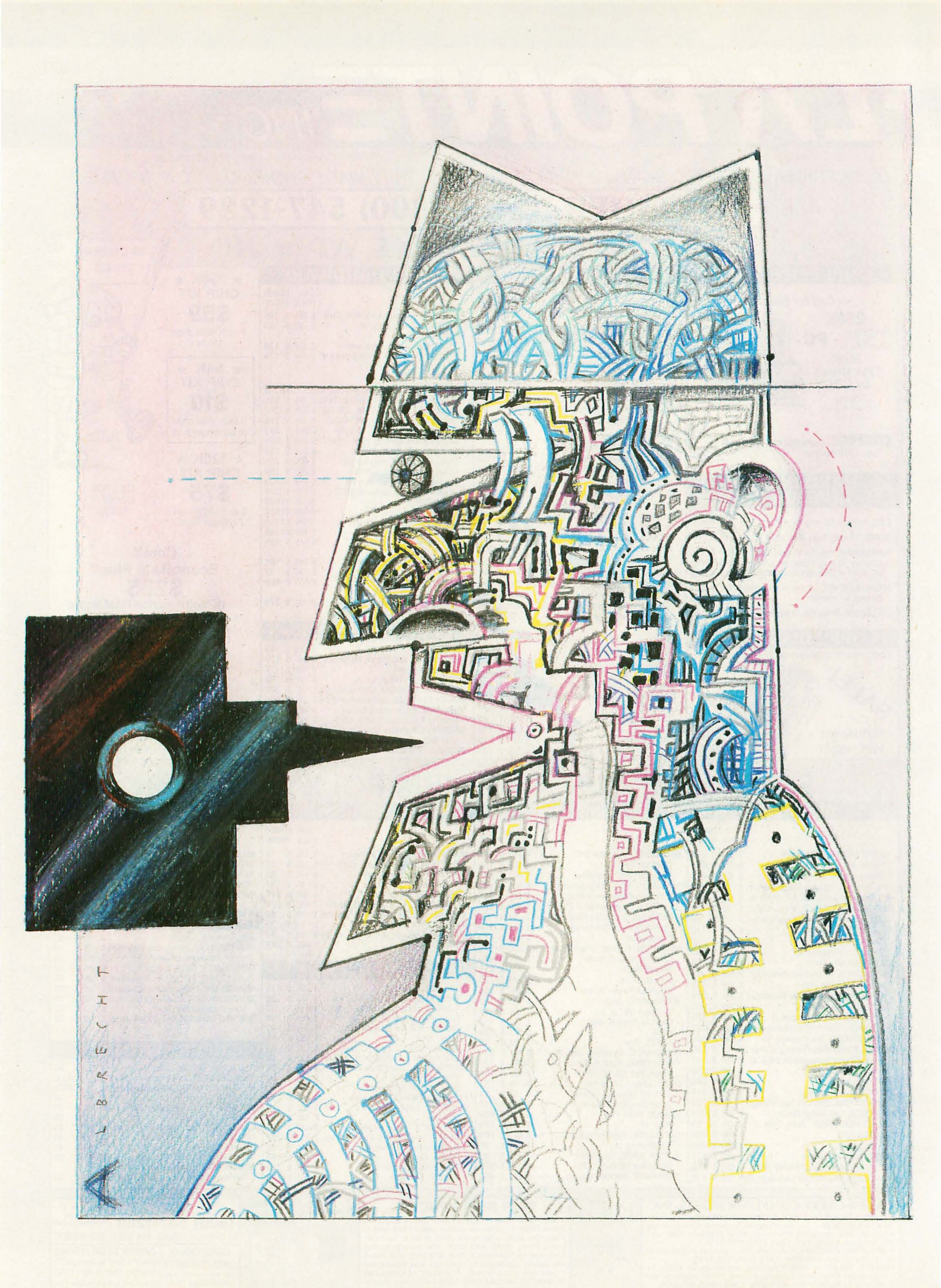


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ALBRECHT

Declarative Languages

THE THEME OF THIS ISSUE is a programming paradigm called declarative programming, which offers a new look at computing. The major goals of declarative programming are to provide structurally transparent languages, so programs can be verified and optimized mechanistically, and to facilitate the implementation of multiple-instruction, multiple-data parallelism in the coming generation of parallel-processing computers. The way that declarative languages attempt to achieve these goals is by separating the task that the program is to perform from the way that the computer is to do it. That is, unlike imperative programming languages, declarative languages do not specify the flow of control but only the flow of data in a program.

Declarative languages did not grab the attention of most programmers until the Japanese chose to use Prolog as the programming language for their Fifth Generation Computer Systems (FGCS) project. While that project appears now to be mired in bureaucratic difficulties, the interest it sparked in Prolog lives on. We begin the theme with an article on Prolog by Clara and John Cuadrado. They present a brief introduction to the language, take a look at what the FGCS project hoped to achieve, and provide an overview of the hardware and software available that is taking Prolog beyond the development stage into the realm of finished and viable commercial products.

Next, Robert Kowalski discusses why logic programming is such an attractive development tool in the first place. As you may know, Dr. Kowalski was one of the originators of Prolog and has been a major force in the refinement of logic programming to its current high state of sophistication.

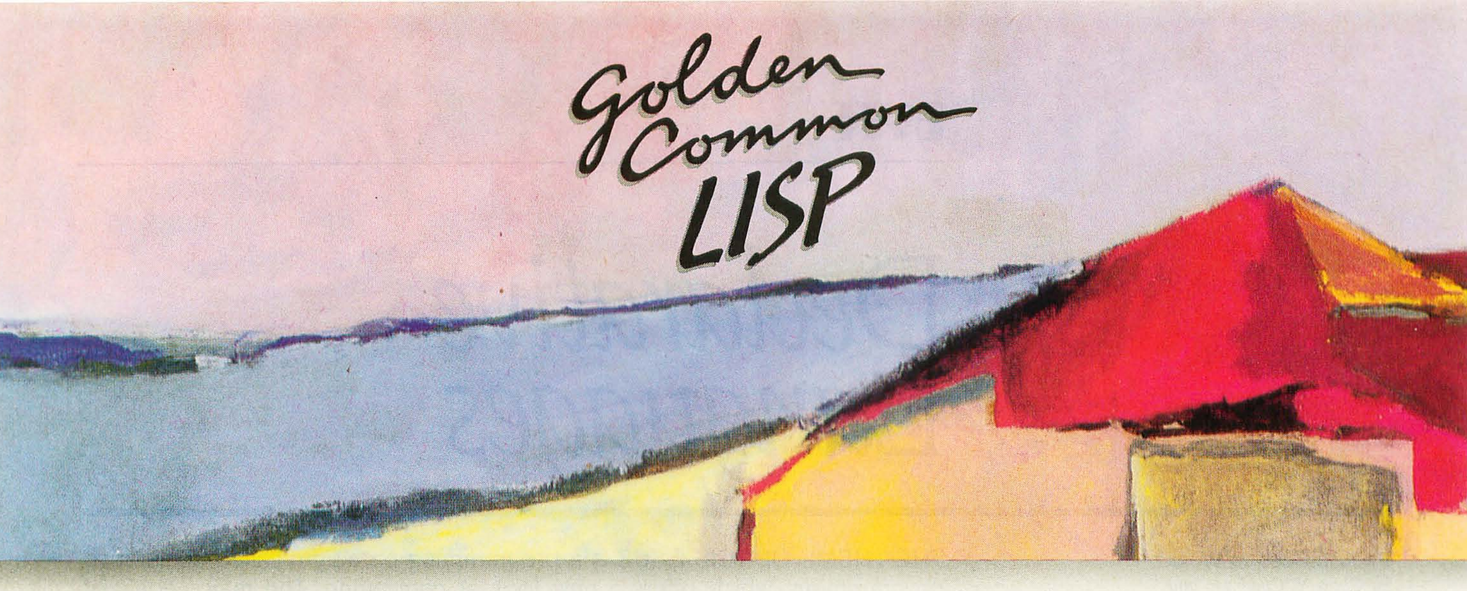
The rest of the issue concentrates on declarative-language developments that are not yet polished commercial products. To begin, Chris Sadler and I briefly outline the declarative-language enterprise and present sample programs in each of the better-known declarative languages.

Next, John Darlington explains program transformation, a method of optimization that seeks to ultimately provide a purely computer-generated optimization. As Dr. Darlington details in his article, that ideal is not yet at hand. However, substantial progress in that direction has already been made.

John Backus introduced the syntax of FP in his famous 1977 Turing Award lecture. Peter Harrison and Hessam Khoshnevisan detail the current state of development of FP in their article. They include a number of programming examples that communicate the flavor of this much-discussed but seldom-seen language.

Finally, Roger Bailey provides an in-depth tutorial on the Hope language. Of course, the only way to evaluate a language is by using it. To allow you to get your hands on Hope, Imperial College's Victor Wu has written a Hope interpreter that runs on MS-DOS machines and can be downloaded from BYTEnet Listings at (617) 861-9774. BYTEnet Listings also contains a public-domain version of Prolog, made available by Automata Design Associates.

—*Susan Eisenbach*



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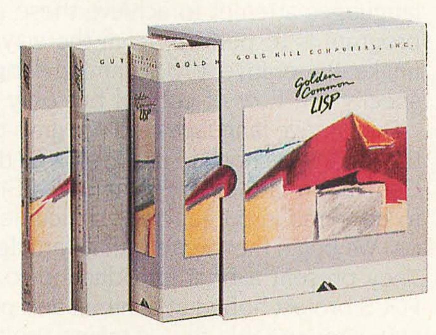
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PROLOG GOES TO WORK

BY CLARA Y. CUADRADO AND JOHN L. CUADRADO

What Prolog is, who's using it, and why

LOGIC PROGRAMMING, simply put, is using symbolic logic as a programming language.

Logic-programming languages are by nature declarative. They are fundamentally different from the more traditional, imperative (or procedural) programming style. When we program in imperative languages (e.g., FORTRAN, Pascal, Ada), we are machine-oriented: We "prescribe" the manner in which we want the computer to go about solving the problem, i.e., we explicitly specify the detailed flow of control necessary to carry out a given computation. In using logic programming to solve problems, we describe or "declare" the logical structure of the problems. [*Editor's note: Robert Kowalski discusses some procedural aspects of Prolog in "Logic Programming" on page* 161.] A typical logic-programming statement may be

smart(X) if reads(X, byte)

for "You are smart if you read BYTE."

To further illustrate the difference between a declarative programming language such as Prolog and imperative languages, we have constructed a simple maze for a treasure hunt (figure 1). The objective is to get through the maze, find the treasure, avoid the various dangers, and come out the other end. Let's approach this problem logically.

First, we express the connectivity of the maze by simple facts like

adjacent (cave_entrance,trolls).
adjacent (fountain,mermaid).

Next we define a predicate, path (Here,There,Dangers,Trail), which is used to accumulate nodes (the locations of interest) in a path going from Here to There and make the result available in Trail. The idea is very straightforward: We can get from Here to There if we can get from Here to some Intermediate location and then from the Intermediate location to There.

In order to avoid going around in circles, we also specify that, whenever we choose a new Intermediate location, it should not be one that we have already visited.

Dangerous locations, such as those where bandits or trolls might be lurking, are easily avoided: Whenever we choose a new Intermediate location, we check to see that it is not one of those that have been designated as dangerous.

Listing 1 is a short Prolog program implementing these ideas. With the aid of the short comments provided (enclosed by /* */), anyone can easily follow the logic without knowing the programming language itself. Notice that we simply specify *what* the predicate path is supposed to accomplish, and not *how* it should do it. The Prolog interpreter does it automatically through its unification and backtracking mechanisms. [*Editor's note: Robert Kowalski's text box "The Origins of Logic Programming" on page* 192 *discusses the concept of backtracking further.*]

Now, to achieve the same objective using an imperative language, we would have to specify an explicit flow of control for the path procedure, including the explicit control of the

(continued)

Clara Y. Cuadrado and John L. Cuadrado (Octy Inc., 10920 *Oxford Court, Fairfax Station, VA* 22039) *both earned Ph.D.s from the University of Illinois at Urbana-Champaign. They taught at the University of Maryland and Dartmouth College, respectively, and now run their own company developing AI systems.*

depth-first traversal of the graph as represented by the maze.

Logic Programming and the Software Crisis

The distinction between the implicit, interpreter-supplied flow of control demonstrated in our simple Prolog program and the explicit, user-specified flow of control of imperative languages is not merely an aesthetic one. D. A. Turner, for instance, suggests that the fundamental cause of the software crisis is the imperative and machine-oriented nature of the programming languages being used (see reference 1).

At the risk of being digressive, we think it important to say a word or two here about the software crisis and its possible alleviation through declarative programming, if only to argue that declarative programming is not only good for the soul but may also be good for the pocketbook.

Figure 2, showing the software and hardware costs as a proportion of total computer costs, has been flashed through projectors in conferences so many times that it is a familiar sight to many, but the point it makes remains too powerful to ignore. It indicates that something is terribly wrong with our conventional way of producing and maintaining software.

The lack of referential transparency is demonstrated by the assignment statement: A variable can be given different values at various locations in the program, thus overwriting the old values. As a result, the meaning of a variable becomes position-dependent, making program verification and program transformations very difficult. [*Editor's note: John Darlington discusses these issues in greater detail in "Program Transformation" on page* 201.] Many of the transformations that are easily applicable to declarative languages are simply not available for imperative languages (reference 2).

The verbosity of an imperative language like FORTRAN (the more modern ones like Pascal and Ada tend to be even worse) comes as a result of the need to specify each control path through the program in explicit detail. Then, after large programs have been written, it is very difficult to figure out what they do, partly because of the sheer volume of the code, partly because the problem-solving logic cannot be made transparent in this manner.

Studies have shown that the amount of code a programmer produces tends to be essentially constant regardless of the specific programming language used. It is obvious that the fewer lines of clearer code we use to accomplish a task, the better. And a logic-programming language seems to be the perfect candidate for getting more work out of fewer lines of code. We would like to offer a bit of personal experience to document this point.

A few years ago, while working on various data-flow models for high-performance signal-processing systems (reference 3), we found it necessary at one point to write a

Listing 1: A *Prolog program to traverse the maze in figure* 1.

```
/* Prolog representatin of the treasure maze */

adjacent(cave_entrance,trolls).     adjacent(cave_entrance,fountain).
adjacent(fountain,limbo).           adjacent(fountain,food).
adjacent(fountain, bandits).        adjacent(fountain,mermaid).
adjacent(bandits,treasure).         adjacent(bandits,exit).
adjacent(food,treasure).            adjacent(trolls,treasure).
adjacent(mermaid,exit).             adjacent(treasure,exit).

avoid([trolls,bandits]).            /* the places to stay away from */

/*
     The following is a predicate to display a path through the
     maze avoiding the Dangers and passing through the treasure room.
     To invoke it use:
          traverse(cave_entrance,exit).
*/

traverse(Here,There) :-
     avoid(Dangers),            /* grab the list of places where not to go
     path(Here,There,Dangers,[Here]).

/* see text for explanation of the path predicate below */

path(Here,Here,Dangers,Trail)   :-
     member(treasure,Trail),    /* make sure we go by the treasure room */
     reverse_write(Trail),      /* print the trail starting with Here */
path(From,To,Dangers,Trail) :-
     (                          /* choose an Intermediate location */
      adjacent(From,Intermediate)
     ;
      adjacent(Intermediate,From)
     ),
     not member(Intermediate,Dangers),       /* is it a dangerous place? */
     not member(Intermediate,Trail),         /*  have we been  there before? */
     path(Intermediate,To,Dangers,[Intermediate|Trail]).     /* extend path */

/* next, print a list in reverse order */

reverse_write([]).
reverse_write([Head|Tail]) :-
     reverse_write(Tail),
     nl,
     write(Head).

member(X,[X|_]).
member(X,[_|Y]) :-
     member(X,Y).
```

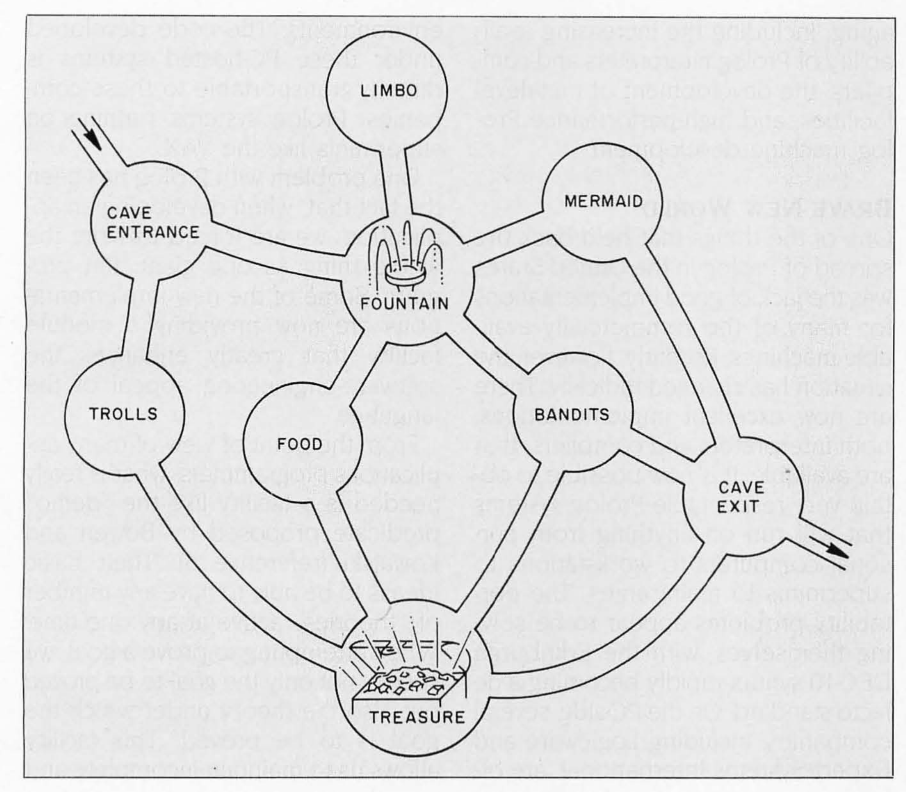


Figure 1: *The maze traversed by the Prolog program in listing* 1.

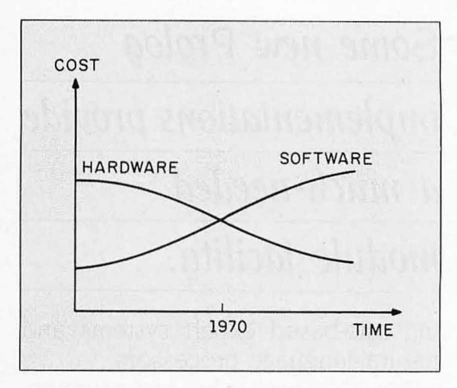


Figure 2: *A qualitative graph of software and hardware cost trends.*

simulator for one of the data-flow models. One weekend we wrote a specification for the simulator. We used Ada as the program-description language (PDL), and the whole thing came to around five pages of code. A colleague spent the next few weeks turning the PDL into a running Ada program, using Telesoft Ada on the VAX. The final program was around 50 pages long and ran reasonably well.

Some months later, we spent another weekend on a similar task, but this time we used Prolog as the specification language. We had not looked at the Ada specification for quite some time so everything was done from scratch. That is, it was not a matter of simply rewriting the Ada specification in Prolog. The new specification in Prolog was also around five pages long. The difference was that this time the specification *was* the implementation. It ran the first time we tried it, and, much to our surprise, it actually ran faster than the Ada version. It should be pointed out here that this was not intended to be a controlled experiment, and the speed factor is probably not very meaningful, given the state of Ada code generators back in 1983. On the other hand, the Prolog interpreter we were using at that time was the University of New Hampshire's interpreter, developed by Jim Weiner. We have a feeling that, even if we could use a very advanced Ada code generator, we would probably still come out ahead using Quintus Prolog on the VAX today. We haven't tried it.

THE FGCS PROJECT AND LOGIC PROGRAMMING

Now that we are on the topic of practicality, we should mention the Japanese connection. Only a few years ago, not too many people knew about logic programming. Then the Japanese announced that they had chosen logic programming and Prolog for their ambitious, long-term, nationwide effort known as the Fifth Generation Computer Systems (FGCS) Project.

Among the expressed objectives of the FGCS project is the development of fast, intelligent computer systems with the following capabilities: human-like decision making and learning, natural language and voice I/O (input/output), automatic program generation, and distributed processing.

The project has since been dubbed the "computer science Pearl Harbor," but at the time the greatest surprise to many was the Japanese commitment to Prolog and logic programming. Since then, many people have studied logic programming in earnest. Some of us have even turned evangelical about it.

We will not debate whether, as Kowalski maintains, the Japanese are more objective and insightful and therefore were able to see before the rest of the world that logic programming was "the right way to go" (reference 4). There are less controversial ways to enter the subject. Figure 3, borrowed from Moto-Oka (reference 5), represents a conceptual diagram of a fifth-generation computer system from the programming standpoint.

In the FGCS project, logic programming is envisioned as the link between the fields of software engineering, database systems, computer architecture, and knowledge engineering. It is to be used for problem specification and transformation, unifying functional programming and relational databases, developing single-assignment languages, and construct-

(continued)

Some new Prolog implementations provide a much-needed module facility.

ing rule-based expert systems and natural-language processors.

The FGCS project has had a tremendous effect in spurring new research and development in computer science in the United States, not only in academia and in government but in commercial establishments as well. An indication of the impact that logic programming is making on the U.S. computer industry is that a LISP stronghold like Symbolics Inc. is now offering a Prolog compiler for its 3600 series of LISP machines. In the following sections, we will discuss some recent developments in logic programming that are particularly encouraging, including the increasing availability of Prolog interpreters and compilers, the development of metalevel facilities, and high-performance Prolog machine development.

BRAVE NEW WORLD

One of the things that held back the spread of Prolog in the United States was the lack of good implementations for many of the commercially available machines. Recently, however, the situation has changed radically. There are now excellent implementations, both interpreters and compilers, that are available. It is now possible to obtain very respectable Prolog systems that will run on anything from personal computers to workstations to superminis to mainframes. The portability problems appear to be solving themselves, with the Edinburgh DEC-10 syntax rapidly becoming a de facto standard. On the PC side, several companies, including Logicware and Expert Systems International, are offering integrated Prolog development environments. The code developed under these PC-hosted systems is directly transportable to these companies' Prolog systems running on superminis like the VAX.

One problem with Prolog has been the fact that, when developing an application, we are forced to write the whole thing as one giant, flat program. Some of the new implementations are now providing a module facility that greatly enhances the software-engineering appeal of the language.

From the point of view of many applications programmers, what is really needed is a facility like the "demo" predicate proposed by Bowen and Kowalski (reference 6). Their basic idea is to be able to have any number of "theories" active at any one time. When attempting to prove a goal, we specify not only the goal to be proved but also the theory under which the goal is to be proved. This facility allows us to maintain incomplete and

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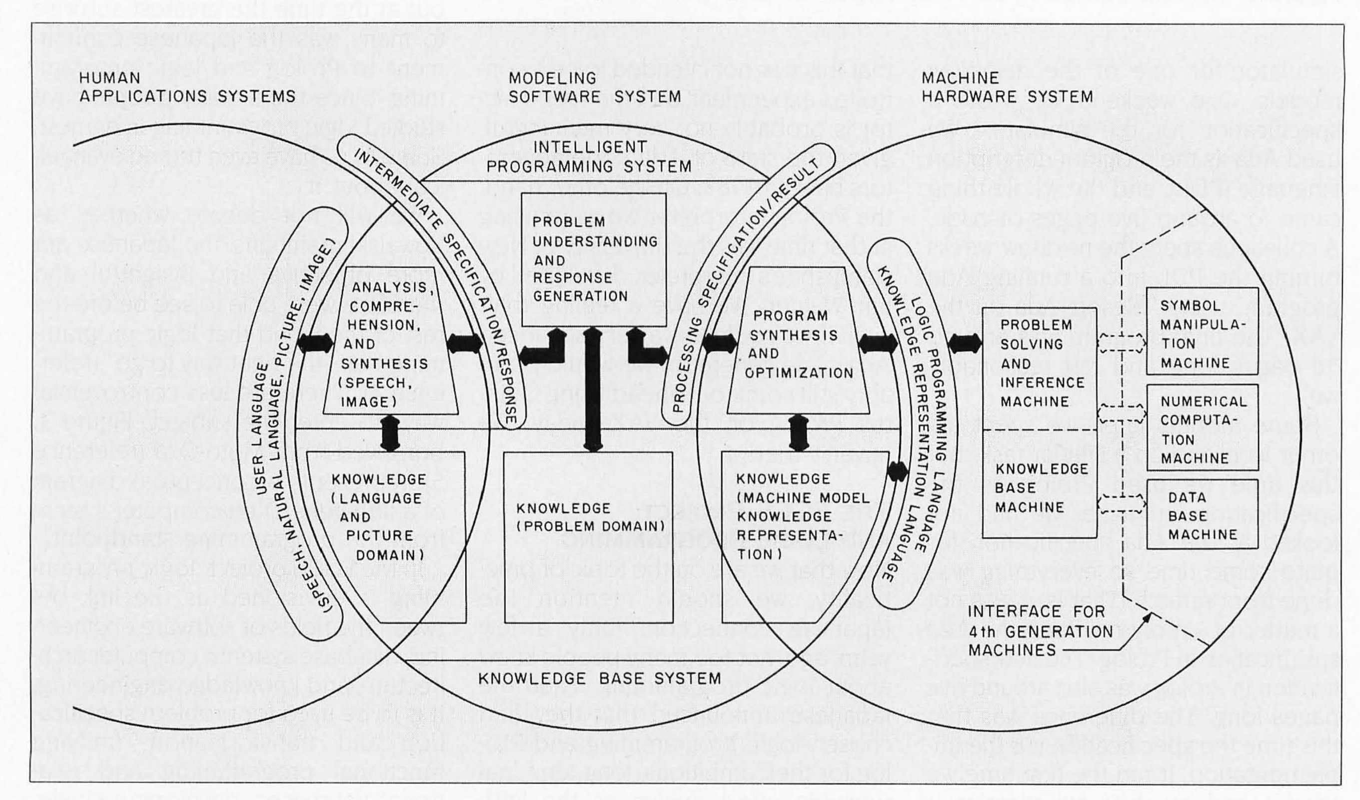


Figure 3: *A conceptual diagram of a fifth-generation computer system. Reprinted with permission from* Fifth Generation Computer Systems, *T. Moto-Oka, ed.* (*New York:* Elsevier, 1982, *page* 29).

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even inconsistent theories about an object of interest. It provides us with a very attractive mechanism for the implementation of nonmonotonic features.

Recently, Ken Bowen has made substantial progress in implementing these ideas (reference 7). While adding new facilities to standard Prolog, he has painstakingly avoided straying outside the realm of logic. This is an important consideration: It is relatively straightforward to "enhance" a Prolog system by introducing extralogical features such as state-dependent features and user-controlled agendas. The problem is that by providing these things we destroy the well-understood logical foundations upon which logic programming is based. As such, the features that make logic programming attractive in the first place quickly become inapplicable.

Over the past few years a group of researchers in the Computer Science Division of the University of California at Berkeley, headed by Al Despain and Yale Patt, have been investigating the design and implementation of very high performance architectures to support a mixture of numerical and symbolic computations. After looking at various declarative languages such as John Backus's FP, they decided that logic programming offered the best avenue to pursue their goals.

Armed with an extraordinary knowledge of computer architecture, they launched their Prolog Machine (PLM) project, using the work of Tick and Warren (reference 8) as a starting point. A Prolog compiler targeted to the PLM instruction set was written. This compiler, with numerous recent improvements, performs some of the most ambitious data-flow analyses ever attempted for Prolog programs.

The PLM hardware is currently implemented as three wire-wrapped boards and runs as an attached processor on the NCR/32. At the time of this writing, most of the hardware has been debugged and all the microcode has been checked out. The timings predicted by the simulator appear to be very realistic, and the system running on the NCR bus is capable of supporting 305,000 LIPS (logic inferences per second). With a different high-performance bus designed by the Berkeley group, the system will support 425,000 LIPS (reference 9). These numbers are almost an order of magnitude better than anything available until very recently.

While we are on performance, we have been told that the Symbolics Prolog will be able to achieve around 100,000 LIPS (reference 10) when all the microcode support is in place and the system has been carefully optimized. We are currently using a beta-test version of it and like the fact that

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the entire Symbolics machine development environment is available. For people who are already familiar with the Symbolics machine, it probably offers the best commercially available facilities for developing Prolog applications at the present time.

The world of logic programming is rapidly expanding. There are currently ongoing projects, ranging from expert systems to image processing, that will produce very large systems written entirely in Prolog. Logic programming has won lots of supporters in this country in a short period, and the future looks bright. ■

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Editor's note: A screen-oriented implementation of Edinburgh-syntax Prolog has been placed in the public domain by Automata Design Associates and is available for downloading from BYTE*net Listings at* (617) 861-9774.



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LOGIC PROGRAMMING

BY ROBERT KOWALSKI

Prolog can be used as either a declarative or a procedural programming language

LOGIC PROGRAMMING is based upon attempts begun in the early 1950s to mechanize the proof of mathematical theorems by means of computer. Those attempts were only partially successful. However, the early 1970s brought the discovery that computation is a special case of mechanical, logical deduction. The key to this discovery was the development of mechanical theorem provers that use logic to prove theorems by means of *backward reasoning*.

Simple backward reasoning was not powerful enough to prove significant theorems of mathematics. However, applied to sentences of the form "conclusion if conditions," it behaves like procedure invocation. Such backward reasoning is the basis of both logic programming and the computer language Prolog.

Backward reasoning has two main uses. First, a problem solver can automatically add it to knowledge expressed in logic to obtain machine-executable procedures. This allows us to use logic as a purely *declarative* language in which we express knowledge without worrying about how to use it. In addition, we can explicitly use backward reasoning to control the reduction of problems to subproblems. This allows us to use logic as a purely *procedural* programming language.

LOGIC AS A DECLARATIVE LANGUAGE

The following is probably the most familiar of all examples of logical reasoning. It shows how backward reasoning turns declarative statements into procedures.

All humans are mortal.
Socrates is human.

We can express the two English sentences more formally, each with a single conclusion and several—or possibly no—conditions. The first sentence, for example, has one conclusion, *x* is mortal, and one condition, *x* is human, where the variable *x* stands for any individual. The second sentence has the same structure: It, too, has a conclusion, *Socrates* is human, and a trivial, vacuous condition. Together, these sentences have the same conclusion-conditions form:

x is mortal
  if *x* is human.
Socrates is human
  if nothing.

You can express a surprising amount of knowledge in this simple form. We call sentences expressed in the conclusion-conditions form "Horn clauses" in honor of logician Alfred Horn, who studied their logical properties.

Backward reasoning turns knowledge expressed as Horn clauses into procedures. The very first sentence above, in particular, becomes a procedure that, given *x* such as *Socrates*, reduces the problem of showing that *x* is mortal to the subproblem of showing *x* is human.

In general, backward reasoning works backward from the conclusion of a sentence having the form "conclusion if conditions" and reduces problems that match the conclusion to subproblems corresponding to the conditions.

Even the sentence "Socrates is human" can be used as a procedure, to show "Socrates is human" by doing nothing. It solves problems directly, reducing them to no further subprob-

(continued)

Robert Kowalski is professor of computational logic and head of the logic programming group at Imperial College, 180 Queen's Gate, London SW7 2BZ, England.

lems. Taken together, we have the two procedures

To show *x* is mortal,
 show *x* is human.
To show *Socrates* is human,
 do nothing.

But the same declarative knowledge can give us other procedures. If, instead of showing that Socrates is human, we want to find an individual who is mortal, then, using the first sentence, we get a procedure that finds mortals by finding humans. Using the second sentence, we get a procedure that finds humans by letting the individual be Socrates. Taken together, we have the procedures

To find *x* which is mortal,
 find *x* which is human.
To find *x* which is human,
 let *x* be *Socrates*.

We obtain the new procedures from the same knowledge by the same general method of backward reasoning. Moreover, backward reasoning itself is sufficiently mechanical that we can implement it on a computer.

Logic as a Procedural Language

A programmer can also use backward reasoning deliberately to control the reduction of problems to subproblems. Suppose, for example, I want to find something to sell to a customer, John. I can try to solve the problem by reducing it to subproblems. The first thing I might do is try to find out what John does for a living. Then I might try to find something that John can use for his occupation. To find something to sell to John, first I'd find out what John does (e.g., gives lectures, watches films, writes programs), then find something that John could use for his work (e.g., an overhead projector for giving lectures, a television for watching films, Prolog for writing programs). Having solved the two subproblems, I have found something I can now try to sell to John, namely an overhead projector, a television, or Prolog.

We can analyze the procedure as backward reasoning applied to knowledge expressed in conclusion-conditions form:

x is sellable to *y*
 if *y* has occupation *z*
 and *x* can be used for *z*.

Prolog, for example, will use this knowledge as a procedure to solve subproblems in the order in which the conditions are written, first finding customers' occupations, then finding goods that can be used for such occupations. Prolog programmers, therefore, can control the order in which the computer solves subproblems by controlling the order in which they write those subproblems.

Thus, not only can we use logic purely declaratively, but we can use it purely procedurally. In between these two extremes is a spectrum of uses. In many expert systems, for example, the programmer determines the general problem-reduction structures, but the "inference engine" makes its own lower-level problem-solving decisions. Our rule for selling goods to customers, for example, can be regarded as the beginning of a salesman's simple expert system.

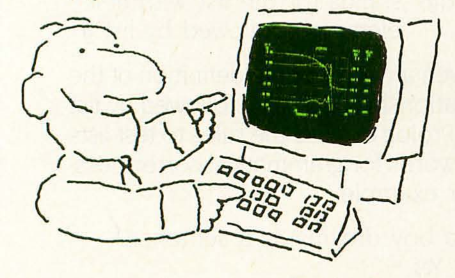
For the sake of efficiency, Prolog uses a simple problem-solving strategy. It solves subproblems in the order in which the programmer has written them and also tries different ways of solving a subproblem in the order in which the programmer has written the conclusion-conditions rules. As a consequence, we can implement Prolog comparatively efficiently and control its behavior easily. The disadvantage is that if you use Prolog purely declaratively, the arbitrary order in which you write conditions and rules may not be appropriate for all problems.

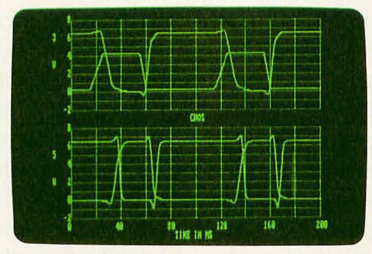
Consider, for example, using the

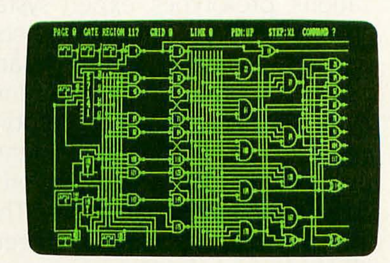
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salesman's rule to find customers for Prolog. If you use Prolog itself to solve the problem, it tackles subproblems in the order in which you have written them, first finding pairs of potential customers and their occupations, then showing that Prolog can be used for such occupations. This is not an appropriate order in which to tackle the subproblems. In general, although the same procedures may be appropriate for solving a wide range of problems, for the sake of efficiency, the strategy used to solve subproblems may need to be sensitive to the form of the problem to be solved.

In this particular case, a problem solver should first find out what activities Prolog can be used for and then find out who engages in those activities. Once users know they can use Prolog for implementing specifications, prototypes, expert systems, and databases, they can find someone who is engaged in those activities (e.g., software engineers implement specifications and prototypes, engineers of all kinds implement expert systems, data-processing professionals implement databases). Therefore, software engineers, engineers of all kinds, and data-processing staffs are potential customers for Prolog.

This example shows that you can solve subproblems in any sequence. Indeed, for the sake of efficiency, you may need different sequences for different problems. Database-query languages, for example, use query optimizers to determine the order in which to solve subproblems.

Much current research in logic programming is devoted to developing more intelligent problem solvers and to exploiting the possibilities of tackling subproblems in parallel. If the Japanese Fifth Generation Project succeeds in its aims, computers of the future will consist of communities of problem solvers working in parallel on subproblems generated by procedures expressed in logical form.

BACKWARD VS. FORWARD REASONING

Backward reasoning, which links logic with computation, is not taught in conventional logic books. Conventional logic teaches us to reason forward, in the same manner that mathematics teaches us to demonstrate proofs: We start with axioms, definitions, and previously proved theorems, and, as if by magic, in the last step we derive the theorem to be proved. Rather than give a mathematical example, we can illustrate the difference between forward and backward reasoning with an example from natural-language parsing. The rule

x is a sentence
  if x is list y followed by list z
  and y is a noun phrase
  and z is a verb phrase

describes one way that a list of words x can be interpreted as a sentence. Thus, the list of words (the boy likes the girl) is a sentence, because (the boy) is a noun phrase and (likes the girl) is a verb phrase. We can use the rule to reason forward as well as backward.

Suppose we are given a list of words and we want to show that we can interpret the list as a sentence. If we use the rule to reason forward, then we find a noun phrase and a verb phrase, put them together, and conclude that we have a sentence, whether or not that sentence is the list of words with which we began.

(x) is a noun phrase
  if *x* is a name.
John is a name.
Mary is a name.
(x y) is a noun phrase
  if *x* is an article
  and *y* is a noun.
a is an article.
the is an article.
girl is a noun.
boy is a noun.
(x) is a verb phrase
  if *x* is an intransitive verb.
(x | y) is a verb phrase
  if *x* is a transitive verb
  and *y* is a noun phrase.
dreams is an intransitive verb.
likes is a transitive verb.

Figure 1: *Examples of rules defining the concepts of noun phrase and verb phrase.*

In order to use the rule that defines the concept of sentence (whether forward or backward), we need other rules to define the concepts of noun phrase and verb phrase. (For the sake of simplicity, let's ignore the definition of what it means for a list x to be a list y followed by a list z.) (See figure 1.) Here we have used a variant of the micro-PROLOG SIMPLE notation, which was developed at Imperial College in London, England, for teaching logic as a computer language for children. Variables such as x, y, and z in different rules are actually different, even though they may look the same. We use parentheses for list notation:

( )	stands for the empty list
(x)	stands for the list with one element x
(x y)	stands for the list with two elements, x followed by y
(x|y)	stands for the list with first element x followed by list y

Given an appropriate definition of the relationship "x is list y followed by list z," Prolog can use the rules to test lists of words for grammatical correctness. For example,

(a boy dreams) is a sentence?
  Yes
(a boy dreams a girl) is a sentence?
  No

It can even use the same rules to generate sentences:

x is a sentence?
x = (Mary dreams)
x = (Mary likes Mary)
x = (Mary likes John)
x = (Mary likes the girl)
etc.

Thus, for example, to show that (a boy dreams) is a sentence, Prolog first splits the list into consecutive sublists, tries to show that the first sublist is a noun phrase, and then tries to show that the second sublist is a verb phrase. If at any stage it fails to solve a subproblem, it backtracks and tries a different way of solving the most recent, previously considered subproblem. In this case, it first splits the ini-

(continued)

tial list into the trivial list ( ) followed by (a boy dreams). After failing to show that ( ) is a noun phrase, it backtracks and splits the initial list into the list (a) followed by (boy dreams). After failing to show that (a) is a noun phrase, because (a) is not a name, Prolog backtracks and splits the initial list into the list (a boy) followed by (dreams). It then shows that (a boy) is a noun phrase by showing "a" is an article and "boy" is a noun. It then shows that (dreams) is a verb phrase by showing that "dreams" is an intransitive verb. In this way it succeeds in solving the initial problem by backward reasoning.

It would be harder to describe how to use forward reasoning to search for a solution to the same problem. But it is comparatively easy to show how to use it to give a proof:

"a" is an article and "boy" is a noun.
Therefore, (a boy) is a noun phrase.
"dreams" is an intransitive verb.
Therefore, (dreams) is a verb phrase.
Therefore, (a boy dreams) is a sentence.

This example shows how effective Prolog's simple problem-solving strategy can be. This is not always the case, however, because usually the order in which subproblems are tackled should be sensitive to the form of the problem being solved. Moreover, Prolog's autonomous mode of solving subproblems is not always very effective.

INTERACTIVE PROBLEM SOLVING

In many cases a collaborative, machine-machine or man-machine problem-solving effort is more appropriate. For this reason, Peter Hammond and Marek Sergot at Imperial College have implemented an extension of Prolog in Prolog itself that asks the user for help. This extension, APES (Augmented Prolog for Expert Systems), has been used for many applications not normally associated with expert systems.

For example, given the problem "(Mary likes Bob) is a sentence?" and our toy English grammar, Prolog, reasoning backward, eventually reduces the problem to the subproblem "Bob is a name?" which it cannot solve. At this point, Prolog fails to solve the subproblem and eventually terminates in failure. Logically, however, there is no reason not to obtain the knowledge needed to solve the problem from the user. The user can solve the problem with "Yes" and the computer can store the knowledge for its own use on future occasions. In this way the computer learns from the user. It becomes more knowledgeable, if not more intelligent.

PARALLEL PROBLEM SOLVING

This is an example of man-machine collaboration. Subproblems are solved sometimes by man, sometimes by machine. In general, it is more efficient to collaborate with others, whether they are people or machines, than it is to solve problems on our own.

The classical eight-queens problem illustrates the benefits of such collaboration. The problem is to place eight queens on a chessboard in such a way that no queen can take another.

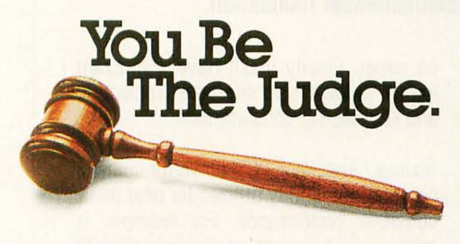
Every well-educated computer scientist knows that you shouldn't write a computer program to solve a problem before you have a clear idea what the problem is. You write a problem definition—the program specification—before you write a solution—the program. Moreover, even computer scientists who do not support the use of logic as a programming language appreciate the value of logic as a program-specification language. In the case of the eight-queens problem, we can use the conclusion-conditions form of logic to express the uppermost level of the program specification:

x solves the eight-queens problem
if *x* is an assignment of queens
and *x* is safe.

Given appropriate definitions of the "assignment" and "safe" relations, a problem solver can turn the program specification into a procedure by applying backward reasoning. However, Prolog's strategy of solving subprob-

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lems sequentially in the order in which they are written is extremely inefficient. Prolog will alternatively generate complete assignments of all eight queens to the chessboard and test whether one queen can capture another. If it needs to find all solutions, then it has to consider all 8^8 complete assignments. Even though this is extremely inefficient, it may still be useful for testing the specification.

Prolog attempts to solve problems sequentially, one at a time in the order in which the user has written them. But other problem-solving strategies can also be employed. In the case of the eight-queens problem, we can employ two collaborating problem solvers working in parallel. One problem solver can generate assignments and the other can test them for safety. The tester can test partial assignments before they are completed. If a partial assignment (of the first two queens, for example) is unsafe, it can reject that partial assignment and thereby reject the entire family of all its extensions. The generator can then backtrack and change the position of the queen that caused the partial assignment to become unsafe. Executing the specification in this way, we obtain the classical algorithmic solution.

The algorithm is equivalent to the program you find laboriously encoded in conventional programming languages and even more laboriously proved correct. By analyzing the algorithm as a particular, collaborative problem-solving strategy applied to the program specification, we obtain an immediate, obvious proof of "program" correctness. The algorithm is correct because it is the program specification executed in a correctness-preserving way.

The natural-language understanding problem also exemplifies the advantages of parallel execution. Consider, for example, the top-level rule

Sentence *x* has meaning *y*
  if *x* has syntactic structure *z*
  and *z* has meaning *y*.

This models the classical decomposition of the natural-language understanding problem to the separate subproblems of determining syntax and determining semantics. Prolog (and classical approaches to language understanding) would solve the subproblems separately, first generating syntactic, then semantic structures.

But the two problems can also be solved collaboratively in parallel. One problem solver can generate syntactic structures, and the other can test them for semantic content. The tester can test partial syntactic structures and reject them if they are meaning-

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less before the syntax generator wastes further effort on them. For example, the attempt to understand the candidate sentence (furious green ideas sleep while others work) can be abandoned as soon as the syntactic analyzer has generated the noun phrase (furious green ideas) and the semantic analyzer has rejected it as meaningless. The argument for understanding natural language by executing syntax generators and semantic analyzers cooperatively as producers/consumers was a major component of Terry Winograd's celebrated Ph.D. thesis, *Understanding Natural Language* (London: Academic Press, 1972).

Several logic-programming languages have the problem-solving facilities needed to run the eight-queens problem and the natural-language understanding problem in collaborative, producer/consumer mode. IC-Prolog, developed by Keith Clark and Frank McCabe at Imperial College, was the first of these languages. A more recent system, MU-Prolog, has been developed by Lee Naish at Melbourne University in Melbourne, Australia. IC-Prolog has also given rise to the more efficient programming-language executors Parlog, developed by Keith Clark and Steve Gregory at Imperial College, and Concurrent Prolog, developed by Ehud Shapiro at the Weizmann Institute. These languages are less powerful problem solvers than IC-Prolog but are more efficient for executing the kind of concurrent processes needed for operating-system applications.

New computer architectures are being developed specifically to exploit the possibility of parallel execution. The Japanese Fifth Generation Project, in particular, has as its main objective the development of highly parallel computers that understand logic as their native language. The ALICE parallel-machine project, led by John Darlington at Imperial College, is pursuing similar objectives.

EXECUTABLE SPECIFICATIONS ARE NOT ENOUGH

The eight-queens and natural-language understanding problems illustrate some of the potential improvements we can obtain by using sequential instead of parallel execution. We should not be misled, however, into concluding that we can always obtain efficient algorithms by clever and more parallel ways of executing program specifications. The sorting problem is a counterexample. A problem solver can execute the top-level specification

x is a sorted version of sequence *y*
  if *x* is a permutation of *y*
  and *x* is ordered

in many different ways, but there seems to be no general execution strategy that converts the specification into an efficient algorithm. This is not to say, however, that we cannot express appropriate sorting algorithms in conclusion-conditions form. Moreover, proving the correctness of such algorithms is much simpler than proving the correctness of conventional programs, because logic programs and logic specifications are expressed in the same formalism.

Thus, we must be prepared to use logic to express efficient algorithms as well as program specifications. But even when it is necessary for a programmer to express such algorithms, the benefits of more intelligent parallel execution can still be worthwhile.

THE BRITISH NATIONALITY ACT

So far we have concentrated on the different problem-solving strategies that are possible with backward reasoning. But better problem-solving strategies are of use only if we can express knowledge in a form to which we can apply such strategies. Work at Imperial College on the formalization of the British Nationality Act of 1981 illustrates some of the power and limitations of the conclusion-conditions form that is required for backward reasoning.

The first subsection (1.1) of the act states: "A person born in the United Kingdom after commencement (of the act) shall be a British citizen if at the time of birth his father or mother is (a) a British citizen or (b) settled in the United Kingdom." The English is

not as clear as it may seem. First of all, it doesn't tell us when the individual becomes a citizen. Second, it doesn't tell us—what we discover later—that it matters whether you're a citizen by this rule or by another. For example, a child born outside the United Kingdom after commencement of the act is a British citizen *by descent* if at the time of birth his father or mother is a British citizen *otherwise* than by descent. The conclusion is not simply that you are a citizen, but rather that you are a citizen by 1.1.a or 2.1.b or some other rule.

After several approximations, we eventually discovered that the logic of this subsection of the law is this:

x acquires British citizenship by
(1.1.*a*) on date *y*
if *x* is born in the U.K.
and *x* is born on date *y*
and *y* is after commencement
and *z* is parent of *x*
and *z* is a British citizen by *w* on
date *y*.

This may seem rather tedious, but it needs to be if we are to be absolutely clear what the law really means. Also, it is necessary to formalize explicitly assumptions that are normally taken for granted. For example:

x is a British citizen by *w* on date *y*

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if x acquires British citizenship by
 w on date z
and z is on or before y
and x has not lost British citizenship between date z and date y.

My colleagues at Imperial College under the direction of Marek Sergot have succeeded in translating a major portion of the act into a form executable by Prolog. They were able to implement a small but significant portion of the act within the confines of a small microcomputer. Using Augmented Prolog they developed a system that could be used interactively to determine British citizenship in a large number of frequently occurring cases. It is remarkable that despite Prolog's simple problem-solving strategy and except for a few loops removed manually by program-transformation techniques, the rules extracted declaratively from the act behave reasonably efficiently as a logic program.

Our interest in the British Nationality Act, however, was not to develop a running system but to study the problems of knowledge representation. The British Nationality Act includes constructs that are difficult to translate into conclusion-conditions form. Consider, for example, the following statement:

A person is a citizen
 if . . .
 and his mother is a citizen
 or would have been a citizen
 if she were male.

What we need to handle such statements is an ability not only to express knowledge about the world but also to express *knowledge about* knowledge about the world. In this example we need to be able to refer to our knowledge about the world, imagine an alternate set of beliefs, and derive consequences from those alternative beliefs. This ability is called *metalevel reasoning*.

We can also use metalevel reasoning to analyze the meaning of subsection (2) of the British Nationality Act: "A newborn infant who, after commencement, is found abandoned in the United Kingdom shall, unless the contrary is shown, be deemed for the purposes of subsection (1), (a) to have been born in the United Kingdom after commencement and (b) to have been born to a parent who at the time of birth was a British citizen, or settled in the United Kingdom." Here, although there are other complications, the really problematic phrase is "unless the contrary is shown." The words "unless" and "contrary" both involve negation. Ordinarily, two negations cancel one another out. This is not so in this case because the word "unless" has a metalevel connotation: "unless P" means "if P cannot be proved." It refers implicitly to the current state of knowledge and can lead to conclusions that need to be withdrawn if new knowledge becomes available.

The metalevel reasoning associated with the word "unless" is called *negation by failure* and was first proposed by Carl Hewitt as a feature of the programming language Planner. Several researchers have investigated its relationship with classical logic within a logic-programming framework. Keith Clark, in particular, has shown, under certain fairly natural conditions, that negation by failure is compatible with classical negation. Negation by failure has a very simple (if sometimes incorrect) implementation in Prolog, using its extralogical features.

Prolog also provides more general (extralogical) facilities for metalevel reasoning. Although these facilities are very powerful and very useful, they are not always consistent with classical logic. There is still a great deal of work necessary to incorporate correct and powerful metalevel reasoning within practical logic-programming systems. Such systems would go a long way toward meeting both the critics of logic programming and the critics of logic.

The Need for Belief Revision

Many psychologists believe that human beings are not logical. Certain schools of artificial intelligence also argue that logic is inadequate for representing knowledge and belief. They argue that logic is rigid and inflexible and that it requires human beings to be consistent and their knowledge to be complete.

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In my opinion, the critics are mistaken. The practical application of logic requires a framework within which new knowledge can be assimilated and beliefs can change. Such a framework for *knowledge assimilation* is completely compatible with logic and has many potential applications both inside and outside computing.

The maintenance of information in computer databases is perhaps the most obvious application. We can regard a relational database, for example, as a special case of a logic program, where all rules have conclusions without any conditions. We can treat the need to change information in a database as a special case of assimilating new information. Moreover, analyzing the deductive relationship between the new information and the current state of the database can assist the process of knowledge assimilation.

Suppose, for example, that we have a database storing relationships between parents and their children, together with "integrity constraints" that include the statement that no one has more than one father. Suppose the current state of the database contains a statement that Harry is father of John. Suppose an update adds new information that Fred is father of John. A conventional database system would reject the update, laying the blame for inconsistency with the record of the second father, Fred. A more logical analysis of the derivation of contradiction, however, would recognize that it is just as likely that the record of the first father, Harry, is incorrect. Indeed, it is even possible that the blame lies with the integrity constraint. Some people might have more than one father—a natural father and a legal father, for example. Thus logic, far from forcing us to be rigid and unchanging in our beliefs, helps us to be more flexible and to identify different ways we can change our beliefs.

Logic programming blurs the conventional distinction between databases and programs. It encourages incremental development of programs in a manner that is similar to database updates. Consider, for example, how we might extend our salesman's simple expert system. We might update our rules to include additional ways of selling goods to potential customers. Bob, for example, who is a compulsive buyer, will buy anything that is cheap. We can add an extra rule to deal with cases like Bob's:

x is sellable to *y*
  if *x* is cheap
  and *y* is a compulsive buyer.

Assimilation of the extra rule changes the knowledge base by extending the class of problems that can be solved. On the other hand, the application of

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our original rule might result in inconsistency. Suppose, for example, that we try to convince John that because he likes watching films and because a cinema is good for watching films, he ought to buy a cinema. We can interpret John's failure to be convinced as giving rise to the new knowledge that a cinema is not sellable to John. When assimilated into the knowledge base, this gives rise to inconsistency that should encourage us to reconsider our rules and in this case might suggest that we modify the original rule by adding an extra condition:

x is sellable to *y*
  if *x* can be used for *z*
  and *y* has occupation *z*
  and *y* can afford *x*.

The addition of the extra condition avoids the inconsistency while it preserves previously derived useful consequences of the original rule.

You can also apply knowledge assimilation to *story understanding*. Given our current understanding of a story so far, a new sentence gives rise to new knowledge to be assimilated. A sentence can be ambiguous, however. Different interpretations of the same sentence may differ with respect to their deductive relationships to the current knowledge base. An incorrect interpretation, in particular, may give rise to an inconsistency, which can turn our attention to other interpretations of the input sentences. We might even be motivated to consider other, more logically relevant interpretations, if the current interpretation bears no logical relationship to the current knowledge base. The Linguistics Department at University College in London is investigating a similar, deductively oriented theory of natural-language understanding based on Dierdre Wilson and Dan Sperber's Relevance Theory.

We might even argue that the development of scientific theories can be regarded as an example of knowledge assimilation. New hypotheses and reports of observations need to be assimilated into the current state of the theory. Does the new hypothesis imply that previous hypotheses were

special cases? Is the report of an observation already implied by the existing theory? Or is it inconsistent? If it is inconsistent, does the fault lie with the theory or with the report? The philosopher of science Imre Lakatos has argued that, if the theory is immature and undeveloped, then it is more reasonable to suspect the theory than the report. If the theory is mature, then it is more reasonable to suspect the report. In either case, logic can help us to identify different ways of restoring consistency.

Such a theory of knowledge assimilation and belief revision is necessary for the practical application of logic programming. Even Prolog provides crude but powerful primitives for manipulating sentences and combining ordinary deduction with metalevel reasoning. These primitives can be and have been used for implementing simple but effective knowledge-assimilation systems.

CONCLUSION

Logic programming combines the use of logic that is congenial to human thinking and logic that is sufficiently goal-oriented to be implemented by computer. It provides a general framework within which many widely differing languages can be developed. It gives scope to the development of both declarative and procedural computer languages as well as to sequential and parallel implementations. Prolog is the first and most important logic-programming language, and it provides a tantalizing preview of the more powerful logic-programming languages of the future. ■

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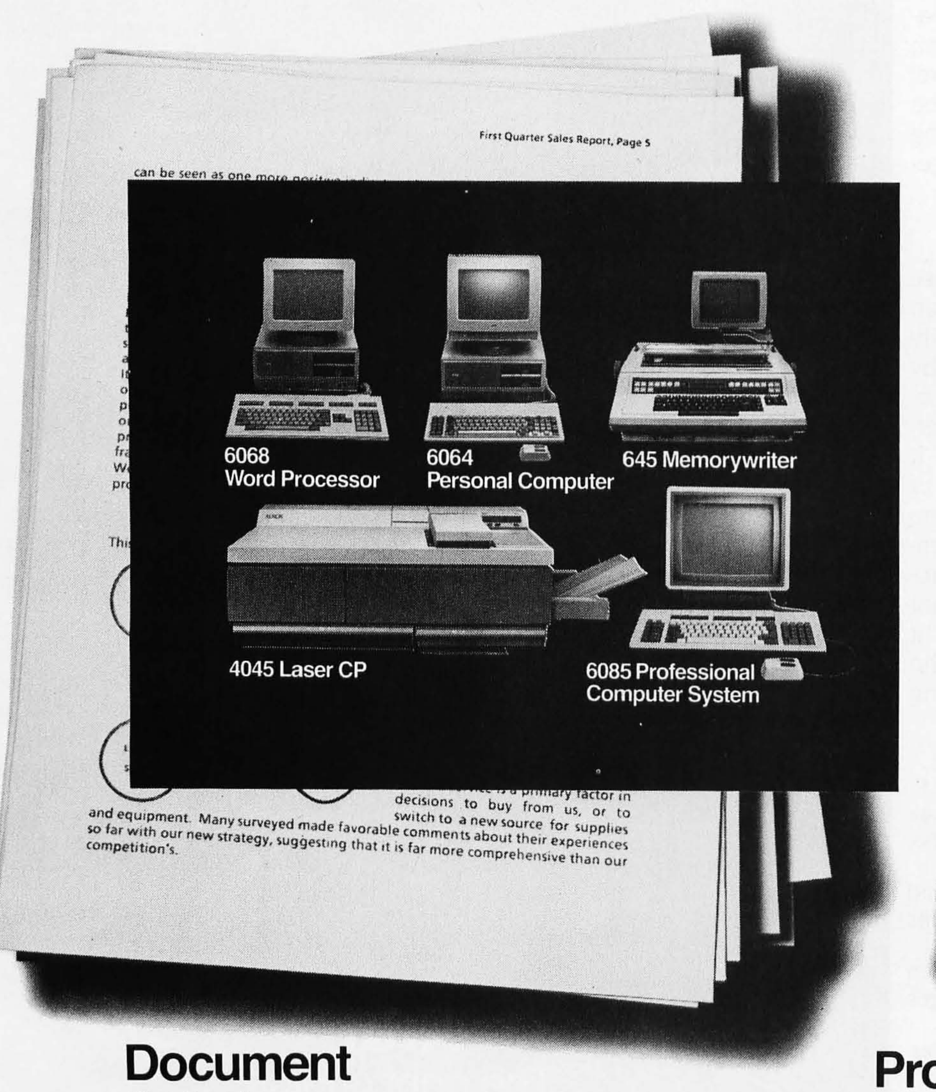
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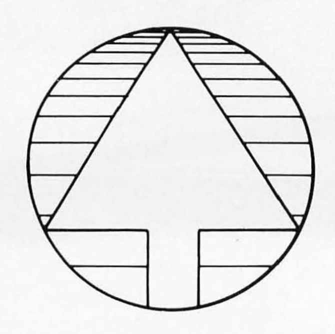
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DECLARATIVE LANGUAGES: AN OVERVIEW

BY SUSAN EISENBACH AND CHRIS SADLER

Why do we need another type of programming language?

SOME PROGRAMMING languages are designed to get the optimum performance out of the systems they run on regardless of the amount of time it takes to produce the program. Others are designed to enhance programmer productivity, usually at the expense of efficient use of machine time. Some are special-purpose languages designed to be applicable only to a restricted range of problems; others attempt a jack-of-all-trades approach by offering features that can be applied to a variety of problems.

Because of the expanding scope and complexity of problems tackled by computers, programming languages tend to exhibit something akin to evolutionary behavior: Some become extinct, some adapt and survive, and some new ones emerge. Underpinning this creation and adaptation of programming languages have been refinements in our understanding of problem solving and programming and changes in our conception of language and machine intelligence. These theoretical considerations have had the effect of founding families of languages. Thus, most languages can trace their parentage back to one or more original ideas. (See the "Development of Functional Languages" text box on page 182.) This article is about one such family, known as the *declarative languages*. Highly regarded in academic circles, declarative languages are problem-oriented but currently inefficient computationally. The imminent fifth-generation hardware makes it look as though the declarative family may soon be entering its own era.

HARDWARE PROBLEMS

Virtually all currently available computers are architecturally equivalent to the first machines built in the 1940s. One central processor is connected to a relatively large passive memory by a bus that is one word wide. Eventually, after much tuning of the software and several hardware upgrades, most systems become processor-bound; the central processing unit isn't fast enough to cope with the tasks it is supposed to perform. At this stage a new computer is normally obtained, with the same basic architecture but faster components. Every breakthrough in hardware technology leads to improvements in speed, which raise the expectations of users that can be met only by another technological breakthrough. Things have reached the stage where not many turns are left through this cycle before we hit some natural barrier (e.g., the speed of light) that closes off the line of development.

One way out of this cul-de-sac lies in an examination of the justification behind the conventional machine architecture. The ratio between processor cost and memory cost used to be high since processors were expensive, requiring many boards of components. Today, this is no longer the case. Both processors and memory are made from the same technologies—LSI (large-scale integration) and VLSI (very large scale integration).

(continued)

Susan Eisenbach is in the Department of Computing, Imperial College, 180 Queen's Gate, London SW7 2BZ, England. Chris Sadler is in the Department of Mathematics, Statistics, and Computing, Polytechnic of North London, Holloway Rd., London N7, England.

Only the smallest microcomputer systems don't have additional special-purpose processors to deal with storage, I/O (input/output) peripherals, floating-point operations, and so on. But there is still only a single central processing unit. For applications that require higher throughput, it makes sense to try to build machines out of networks of general-purpose processors, each of which can take a share of the processing load.

Many current users who require substantial processing power have programs that contain large arrays of data. This is especially true in the areas of meteorology, oil exploration, and defense problems. Therefore, one kind of parallel machine consists of an array of processors that simultaneously obey the same instructions. A high throughput can be achieved if the user's problem can be written to include arrays whose elements all need the same operations performed on them. Another more flexible system consists of a pipeline of processors, each of which performs a portion of the calculation on each piece of data before passing its results on to the next processor down the line. Unfortunately, it is difficult to exploit this

(continued)

THE DEVELOPMENT OF FUNCTIONAL LANGUAGES

FOUNDATIONAL STUDIES

1924 Schonfinkel introduces combinations to remove the need for variables in logical formulae.

1930 Curry develops the theory of pure combinatory logic.

1932 Church introduces the lambda-calculus.

1936 Kleene introduces recursion equations.

1937 Turing shows the equivalence of the lambda-calculus and Turing machines as formal models of computation.

1969 Scott introduces the first mathematical model of the lambda-calculus for use in Scott-Strachey denotational semantics.

FUNCTIONAL LANGUAGES

1960 McCarthy presents LISP, a language similar to the lambda-calculus designed for use in symbolic computation.

1966 Landin introduces ISWIM, an expression-based language including a purely functional subsystem.

1968 Evans introduces PAL, an expression-based language incorporating lambda-notation and designed for use in teaching programming linguistics.

Burstall and Popplestone introduce POP-2, an imperative language that includes a functional subset based on the lambda-calculus. POP-2 is used extensively by the British artificial-intelligence community.

1970 Reynolds creates the language GEDANKEN, which is based on the lambda-calculus and introduces the functional approach to data structures.

1974 Burstall and Darlington develop NPL, a first-order functional language that uses Kleene recursion equations and incorporates relative set abstraction. It was used in their program-transformation work.

1976 Turner introduces SASL, a purely functional language used extensively in teaching.

1977 Hankin and Sharp introduce CAJOLE, a purely functional language designed for use in the programming of data-flow systems.

Backus gives the ACM Turing Award lecture and presents FP, a functional language incorporating powerful program-forming operators.

1978 Burstall and coworkers introduce Hope, a strong polymorphically typed functional language with data-abstraction facilities.

Milner and coworkers introduce ML, the language used to construct proofs in LCF.

1980 Turner introduces KRC, a functional language with Zermelo-Fraenkel set abstraction.

Henderson presents LISPKIT LISP.

1984 Turner introduces MIRANDA.

MACHINES

1965 Landin unveils the SECD machine, an abstract machine for describing the execution of functional languages.

1971 Wadsworth introduces the notions of call by need and graph reduction using the lambda-calculus.

1976 Henderson and Morris invent lazy evaluation. This was also independently invented by Friedman and Wise.

Berkling introduces a string-reduction architecture for executing lambda-calculus programs.

1979 Turner shows how combinators can be used as the machine code of a graph-reduction machine for executing functional programs.

Keller and coworkers introduce AMPS, a loosely coupled multiprocessor system for the execution of flow-graph LISP.

1981 LISP machines become commercially available.

Darlington and coworkers present ALICE, a parallel graph-reduction machine.

Mago introduces a string-reduction machine for the parallel execution of FP programs.

1983 Hughes introduces supercombinators, a method of graph reduction that retains many of the advantages of combinators but operates at a higher level.

lock-step parallelism since not all problems are easily cast into a suitable form.

The next alternative is to use languages that explicitly control the parallel execution of processes. This is called concurrency. New languages such as Modula-2 and Ada have constructs that let the programmer initiate and coordinate multiple concurrent tasks. Typically, these tasks share a single processor, but parallel processors could be used, especially with a limited number of tasks. However, parallel processing becomes less practical to program when the number of simultaneous tasks reaches the thousands.

Just as the procedural languages we use mirror conventional architecture (that is, they are sequential in nature), in order to take full advantage of parallel-processing systems, we need a type of language in which it is natural to describe complex problems in such a way that they can be automatically solved concurrently. One can then gain arbitrary increases in speed simply by adding more processors.

SOFTWARE PROBLEMS

Much research has gone into improving programmer productivity, especially when it was found that the cost of employing teams of programmers began to outweigh the cost of purchasing and maintaining the computers they were using. Two startling findings have made quite a difference in the way things have developed on the software front in the last decade. The first of these is the fact that, whatever programming language is used, any given programmer produces roughly the same number of lines of code—written, tested, debugged, and documented. (The average output for a professional programmer is around 1500 lines per year—although individual production varies widely.) The implication of this finding is that the more powerful the language (that is, the more computing that can be encompassed in each construct, rather than simply the number of different constructs available to the programmer), the more productive the programmer becomes. Thus, over the years we have seen a trend toward higher-level programming languages.

A second trend follows from an analysis of those elements within programs that appear to be particularly prone to error and the elimination of them in new language definitions. This has the effect of limiting the control that can be exercised over the machine at the programmer's whim. The first step in this direction occurred with the move from assembly languages to the original high-level languages. Instead of laying the entire available memory open to the pro-

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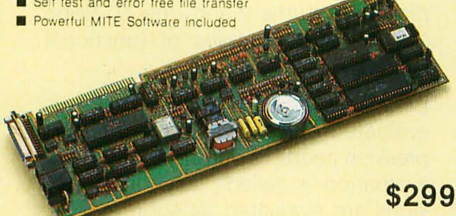
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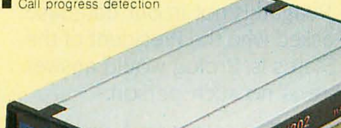
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grammer to access and interpret in any way desired, these high-level languages constrained the programmer to naming storage locations (*variables*) and to declaring the type of data that would be stored there. This step simultaneously restricts the freedom of the programmer to maneuver around the data and imposes a layer of organization (structure) on the data (and hence the program).

The next element to come under the scrutiny of the language designers was the GOTO statement, which seemed to crop up time and again in the more horrendous programming errors. The elimination of GOTO statements gave rise to structured programming, in which programs are built up by means of a set of well-defined constructs designed to ensure a rational and predictable flow of control. Another feature on the blacklist was global data, with its insidious side effects. A new style of programming was developed—modular programming, which restricts programmers to working on small, manageable subproblems and passing all data explicitly between modules. When a problem arises, the offending module can be identified and the effects of the error rapidly traced.

Both structured and modular programming philosophies lend them-

(continued)

Declarative Languages Glossary

APPLICATIVE LANGUAGE: Synonym for "functional language." Often used loosely for any declarative language.

COMBINATORICS: A system for reducing the operational notation of a functional language to a sequence of modifications to the input data structure. All combinators can be defined from two basic combinators—S, which distributes a term throughout an expression, and K, which cancels a term from an expression.

DATA-FLOW ANALYSIS: The order of execution in a data-flow language is determined solely by dependencies between different data. Data-flow analysis is the analysis needed to determine those dependencies. For example, given

1. X = A + B
2. B = 2 + 2
3. A = 3 + 4

a data-flow analysis would find that "A + B" in line 1 requires that lines 2 and 3 be evaluated before line 1. Since there are no data dependencies between lines 2 and 3, they may be executed in parallel.

DECLARATIVE LANGUAGE: A general term for relational languages and functional languages, as opposed to imperative languages. Imperative languages specify procedures for solving problems, while in declarative languages you specify what kind of solution you are seeking. For example, to find the cube of 7 in an imperative language, you might initialize CUBE to 1, and then let CUBE equal CUBE times 7 (repeat 3 times). In a declarative language, you would define what cube means and then ask what the cube of 7 is.

FUNCTIONAL LANGUAGE: A functional language consists of, reasonably enough, functions and arguments to those functions that uniquely identify the program output. For example, plus(4,5) returns 9 and only 9. Hope and FP are examples of functional languages.

LAZY EVALUATION: If an expression is evaluated only when some other expression needs its output, the mode of evaluation is called "lazy." If expressions are evaluated as soon as possible, without regard to whether anything else needs the results, the evaluation strategy is termed "eager."

NEGATION BY FAILURE: An extralogical feature of Prolog in which failure of unification is treated as establishing the negation of a relation. For example, if Ronald Reagan is not in our database and we asked who the President of the United States is, Prolog would answer that there is no such person.

REFERENTIAL TRANSPARENCY: A program is referentially transparent if it prohibits assigning different values to the same named variable during the same run. Functional languages achieve this by using only named constants whose values are passed as data at run time. Relational languages (q.v.) permit the use of variables but require the program to be, in effect, rerun for each different value returned.

RELATIONAL LANGUAGE: Relational languages specify output in terms of some property and an argument. For example, if Tom has two brothers, Dick and Harry, a relational language will respond to the query "Who is brother (Tom)?" with either Dick or Harry. Notice that, unlike functional languages, relational languages do not require a unique output for each predicate/argument pair. Prolog is the best-known relational language.

SIDE EFFECTS: Statements that modify what was previously in a computer rather than simply adding more to what is already there are said to have side effects. For example, "X=X+1" produces side effects. In particular, a statement such as "IF X=2 THEN Y=0 ELSE Y=1" will evaluate differently at different stages in a program's execution. Side effects make parallel processing difficult.

TRANSFORMATION: The systematic development of efficient programs from high-level specifications by meaning-preserving program manipulations.

UNIFICATION: The generalization of pattern matching that is the Prolog equivalent of instantiation in logic. For example, to find the smallest even number larger than 7 that is a perfect square, Prolog would search its "database" of numbers, trying to satisfy the necessary relations between the desired number and 2, 7, and an unspecified integer that is its square root. On coming to 16, the necessary set of relations would be "unified."

selves to an improved correspondence between the specification of a problem (a concise but exhaustive statement of what the program will be expected to do under all circumstances) and the program's final realization (the code running on a given hardware configuration). Nevertheless, this correspondence is usually not rigorous in the sense that no one tends to take the trouble to go through the program actually proving that each module does its job correctly and then passes its results to the right receiving modules in the correct form, even though painstaking mathematical techniques generally exist to do this.

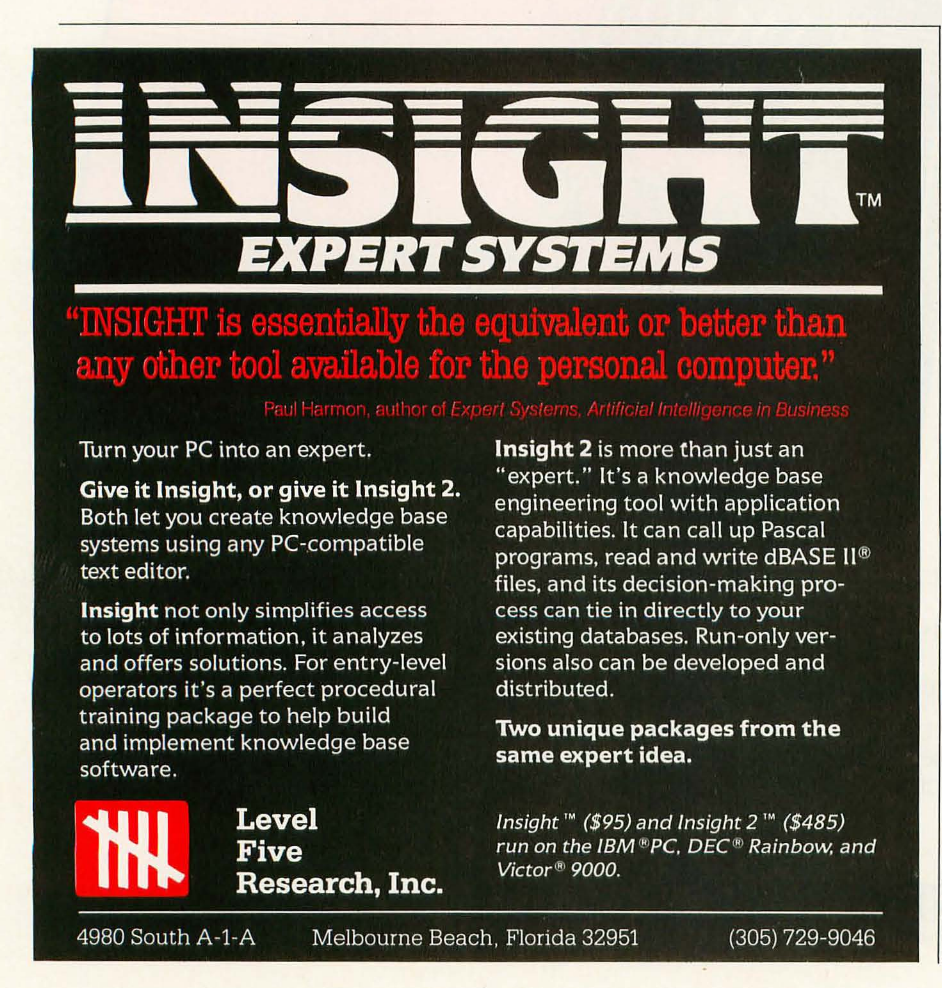
The second startling finding to come out of the research into programmer productivity is that, in the average commercial programming environment, as much as 50 percent of a programmer's effort goes into program maintenance, that is, updating the program's performance to meet circumstances not envisaged when the program was originally specified or hunting for deep-seated bugs. Since deep-seated bugs are simply places where the program, as written, diverges from its original specification, a major improvement in efficiency can be gained from improving the precision of program specifications so that the program can be tied more tightly to its specification. If no specification was produced initially, the maintenance programmer must try to deduce what was intended by examining code that is known to be incorrect.

Making a specification more precise means searching for ways to make unambiguous statements about what the program should achieve. Because the most unambiguous language is that of mathematics, the trend has been toward more mathematical and provable methods of description. By the same token, tying program code to specifications implies not only a trend toward still higher level languages but also toward the use of mathematical methods of proof applied to actual fragments of code. This serves to demonstrate both that the code will have a predictable outcome under all circumstances, rather than those circumstances selected experimentally during testing, and that the outcomes match those called for in the specification.

One noteworthy barrier that prevents the programmer from using reasonably straightforward mathematics for exploring possible solutions to a problem or for testing existing code is the familiar assignment operation. Programmers use the word variable to refer to a named storage location that can be modified by means of assignment statements. Therefore, in order to know what such a variable stands for, it is necessary to know the precise point in the program's execution at which the inquiry is being made—and each variable has a computational history that charts its changing values throughout the program's execution. By contrast, a declarative-language term has a definite value. If that value has not yet been computed, it is simply unknown—it is not some other value. This property is known as *referential transparency*.

In order to make a piece of code amenable to mathematical analysis, it is necessary to free terms from the burden of their computational histories—which means restricting the extent to which programmers may assign values to a term. Languages with referential transparency are known as declarative languages because, without assignments, programmers can declare only what effects should produce what outcomes rather than prescribe the manner and especially the sequence in which processing should occur (these languages are called imperative). Consequently, apart from stabilizing variables so that finite mathematical techniques can be

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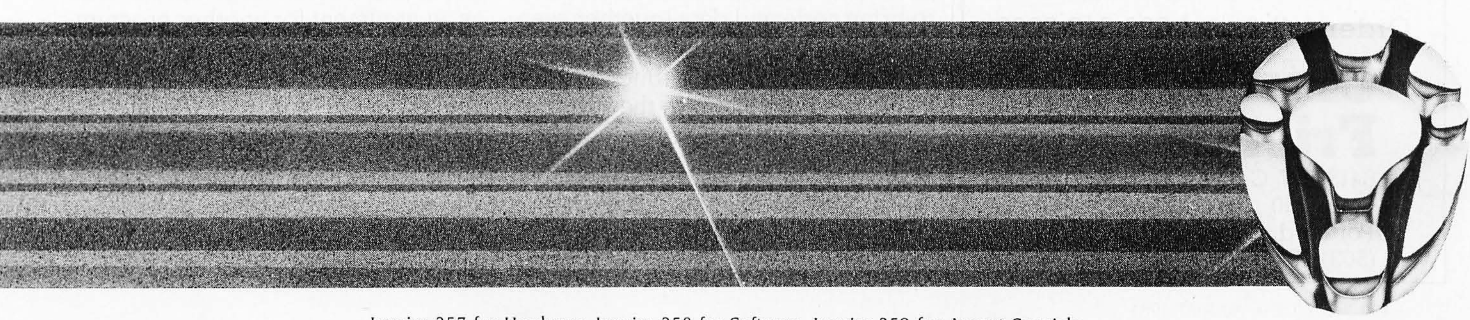
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applied to code fragments, referential transparency serves to remove the flow mechanisms (specifically, sequencing and loops) from explicit mention in the code. This in turn allows for the possibility of parallel processing; since any function in a program can be executed whenever all its inputs exist, rather than when the programmer decides that the processor is available for this purpose, there is no reason why a program cannot be spread over a collection of processors so that each function can get its own processor or share one with a small subset of the whole program.

Referential transparency has other implications for the declarative languages. Since the unknown terms in any expression are simply unevaluated function calls that become known as the function code is executed, one effect is to blur the distinction between functions (code) and terms (data). This leads to the idea of *higher-order functions*, which are implemented in most declarative languages. These functions are capable of accepting as arguments, and also of returning, other first- and higher-order functions so that the programmer can structure and manipulate functions and data with equal facility.

Static data structures such as arrays necessarily have computational histories. They must therefore be replaced in declarative languages by dynamic data structures where memory for an item is allocated only when that item comes into existence. Some imperative languages such as Pascal and C implement these structures rather primitively by means of *pointers* that require the programmer to reference memory locations explicitly. In declarative languages, dynamic structures are treated in more abstract terms (for example, as *lists*). Lists serve to bring code and data together even more closely since they incorporate implicit operations (or functions) for including components in the structure (*constructors*) and for extracting components from the structure (*selectors*). What follows is a brief description of a representative sample of declarative languages, showing some of the differences in approach, mathematical paradigms, and syntax.

PURE LISP

LISP stands for "list processing." It is by far the oldest of the declarative languages, having been designed by John McCarthy at the Massachusetts Institute of Technology in 1960. Numerous imperative features are incorporated into different versions of the language so that most LISP programs are not actually declarative, but a large enough subset (Pure LISP) allows declarative programming to be done. (Peter Henderson of Stirling University in Scotland has a system called Lispkit, which is fully declarative.) LISP has more different dialects than any other declarative language. Since it is the most mature of the declarative languages, a large range of software tools and custom-designed hardware is available. MIT's MacLISP will be used in our programming example.

Data structures in a LISP program are constructed from atoms; an atom is either a numeral or a literal string. Although some LISPs have other data structures, the only standard data structure is the list. Lists need not contain homogeneous elements because LISP is an untyped language. Types are actually determined at run time. For example,

```
( A 1 (ABC 123) )
```

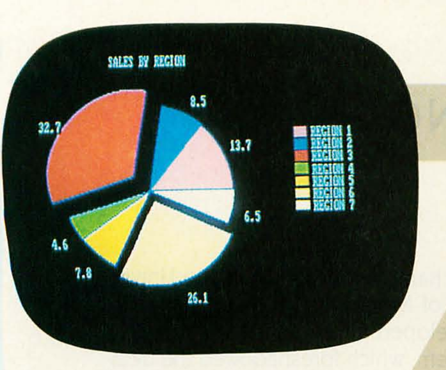
is a list containing three elements. Access methods built into the language include selector functions (car and cdr), constructor functions (list and cons), and a predicate (null) to test for an empty list.

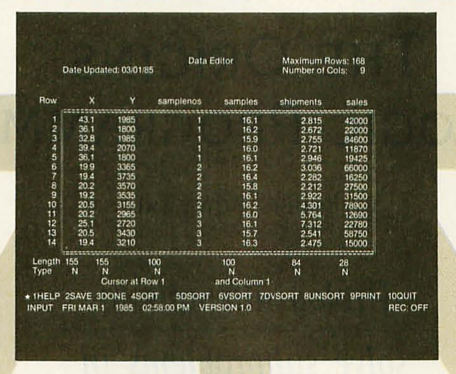
Not only is a LISP data structure a list, but programs are lists as well. Therefore, a list can be executed and will return a value, or it can be used as an argument for another program. Higher-order functions are implemented through a device called the lambda expression, which enables a LISP programmer to define and manipulate functions as data objects. The basic unit of a LISP program is the expression (compared to the statement

(continued)

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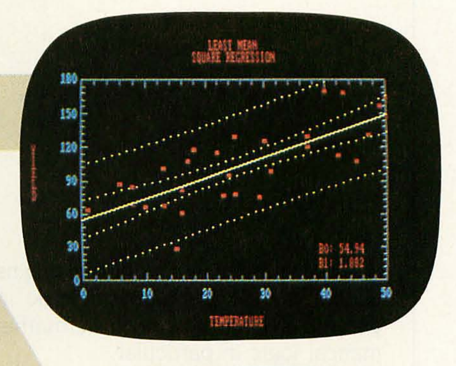
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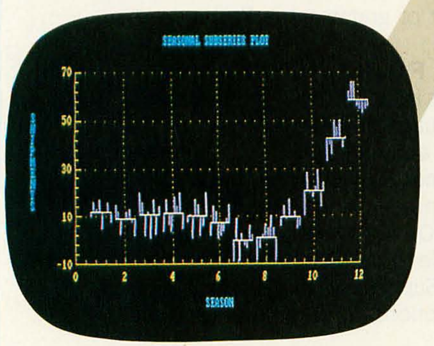
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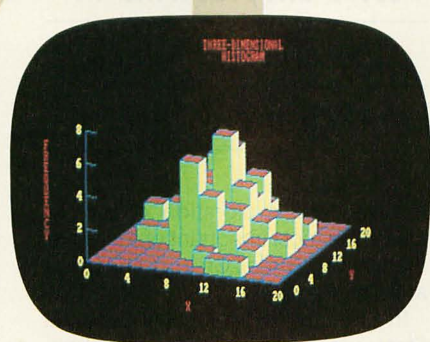
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6	19.9	3365	2	16.2	3.036	66000
7	19.4	3735	2	16.4	2.282	16250
8	20.2	3570	2	15.8	2.212	27500
9	19.2	3535	2	16.1	2.922	31500
10	20.5	3155	2	16.2	4.301	78900
11	20.2	2965	3	16.0	5.764	12690
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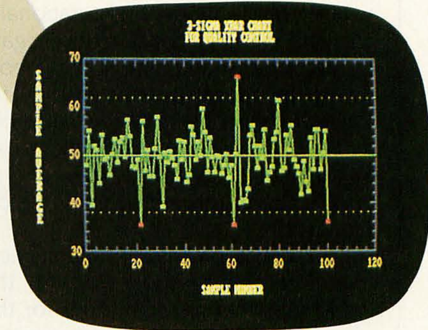
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THE ORIGINS OF LOGIC PROGRAMMING

BY ROBERT KOWALSKI

Logic programming owes its origins to the development of logic in general and to advances in mathematical logic in particular.

In the early 1950s, computationally inclined logicians began to investigate techniques for automating the proofs of mathematical theorems. They reduced the problem to the subproblems of expressing the axioms of mathematics in symbolic logic and of mechanizing the process of logical deduction.

Two developments in mechanical theorem proving took place in the mid-1960s that are significant for the development of logic programming. Alan Robinson developed the resolution rule of inference, and Donald Loveland developed the model-elimination proof procedure. These two theorem-proving methods, expressed in completely different notations, appeared for many years to be entirely unrelated. In 1970–1971 Donald Kuehner and I showed that model elimination and a form of resolution (called *linear resolution*) could be viewed as variants of one another. We developed a synthesis of the two methods, which we called SL-resolution. Independently, at about the same time, Donald Loveland and Raymond Reiter developed similar theorem-proving methods.

In 1972, after a period of collaboration between Alain Colmerauer in Marseille and me in Edinburgh, Colmerauer, with Phillippe Roussel, designed and implemented Prolog as a development of SL-resolution. By the summer of 1972 in Marseille a significant French-language question-answering system had already been implemented in Prolog. Collaboration between Edinburgh and Marseille continued with the support of research grants until about 1975.

A number of research developments outside mechanical theorem proving involved the exploration of related ideas. The most important of these was the work of Cordell Green, Carl Hewitt, and Pat Hayes.

Prolog attempts to solve subproblems in the order in which they are written.

In the late 1960s, Cordell Green at Stanford showed how to formulate programs in symbolic logic and *simulate* their execution with resolution theorem proving methods. This work was frustrated by the redundancy and inefficiency inherent in the resolution theorem provers of that time.

Partly inspired by Cordell Green's problems, Carl Hewitt at MIT developed a procedural theorem-proving language, Planner. The new language had a great influence on the field of artificial intelligence and was interpreted as advocating a procedural rather than a declarative approach to knowledge representation. It was also associated with an advocacy of domain-specific problem-solving methods in contrast to the uniform, general-purpose problem-solving methods of resolution.

Pat Hayes in Edinburgh attempted to reconcile Cordell Green's advocacy of logic with Carl Hewitt's advocacy of procedural knowledge representation. Hayes argued in quite general terms that computation is controlled deduction and that control itself should be expressed in formal logic.

In addition to these developments, Colmerauer was influenced by his previous work in formal language theory and natural-language processing. During his work on French-English mechanical translation at the University of Montreal in the late 1960s, he developed a form of grammar, the Q-system, which foreshadowed the treatment of grammars in Prolog.

THE FALLIBLE GREEK

In his influential Ph.D. thesis on natural-language understanding, Terry Winograd advocated the use of Carl Hewitt's Planner. He illustrated programming in Planner with his example of the Fallible Greek. We can use the same example to illustrate programming in Prolog. Suppose we make the following assumptions, in the following order:

Turing is human	FG1
Socrates is human	FG2
Socrates is Greek	FG3
x is fallible if *x* is human	FG4

Suppose we have to solve the problem of finding a fallible Greek and suppose the subproblems are written in the following order:

y is fallible and *y* is Greek? Q1

Prolog (like Planner) attempts to solve subproblems in the order in which they are written. In this case it matches the first subproblem to the conclusion of the rule FG4 and replaces the subproblem by the condition of FG4, obtaining the new subproblems

y is human and *y* is Greek? Q2

Again, working on the first subproblem, Prolog tries the first statement whose conclusion matches (like Planner). In this case it matches the subproblem to the conclusion of FG1. There are no conditions in FG1, so it solves the subproblem without introducing any new ones, leaving the remaining subproblem with *y* = *Turing*:

Turing is Greek? Q3

But this subproblem is unsolvable because it matches the conclusion of no statement. Therefore, Prolog (like Planner) backtracks to the last state where it could have tried to solve a subproblem differently. In this case it backtracks to the state Q2, where it tries to use the next statement, FG2, whose conclusion matches the subproblem. Like FG1 before it, FG2 has no conditions, leaving the remaining subproblem, this time with the substitution *y* = *Socrates*:

Socrates is Greek? Q4

Prolog now solves the single remaining subproblem in the only possible way by matching it with the conclusion of FG3. Since FG3 has no conditions, there are no new subproblems. Since there are no old subproblems either, Prolog (like Planner) is finished, having successfully solved the original problem. Moreover, the substitution

y = *Socrates*

can be readily extracted from the "proof."

Notice that a more intelligent problem solver, having reached state Q2, might recognize that the database contains more ways of finding humans than it contains ways of finding Greeks. It would make sense, therefore, to tackle the subproblem that can be solved in fewer ways first:

y is human and *y is Greek*? Q2′

The second subproblem can be solved in only one way, using FG3, which leaves the subproblem

Socrates is human? Q3′

But this can be solved only by using FG2, which completes the solution of the original problem without any search.

Such intelligent selection of subproblems is a feature of most database-query optimizers. It is necessary for more intelligent problem solving, but it involves overheads that may be prohibitive for routine program execution.

in most imperative languages), and every LISP construct computes a value. Recursion is the only control mechanism.

As an example of a LISP program, the function shown in listing 1 will calculate the length of a list, l. This program works on a list in which each element can be of any type. In English it says: Length is a function that takes a list as its only argument. If the list is empty, the number 0 is returned; otherwise (represented by the t), the length of the list is one more than the length of the list without the first element.

Prolog

Prolog stands for "programming in logic." (See the "Origins of Logic Programming" text box at left.) Since 1972, several implementations (Marseilles, Edinburgh, Imperial College, and Waterloo, among others) have appeared, each with a different syntax. Preprocessors written in Prolog are available to make programs more readable. In this article, the syntax used is Imperial College's micro-PROLOG with the Simple preprocessor.

Unlike other languages in which programs are formed out of collections of functions, a Prolog program consists of a sequence of relations (assertions) and rules about a subject. These form a database of information that can be queried or added to. Examples of assertions are

```
is–functional( Hope )
is–logic( Prolog )
```

An example of a rule is

```
x is–declarative if (either x is–
functional or x is-logic)
```

Notice the rule has a variable, x. Prolog variables have scope only in the statement where they are defined. The left-hand side of a rule is termed a *goal* and the right-hand side the *subgoals*. To reach a goal, the subgoals must be reached. When the subgoals cannot be reached, Prolog backtracks and searches for another statement that matches an earlier subgoal. This type of logic is called Horn clause logic.

Listing 1: *An example of a* LISP *program.*

```
( defun length (l)
    ( cond ( ( null l) 0 )
        ( t (add1 ( length ( cdr l) ) ) )
```

Listing 2: *An example of a* Prolog *program.*

```
( )    has-length 0
(x|X)  has-length z if
  X       has-length y and SUM (y 1 z)
```

A Prolog query can be used either to discover a fact or to check whether it is true, a feature called *invertibility*. For example, from the relation TIMES((x y z))

```
all (x: TIMES( 4 3 x ))
```

can be used for multiplication, while

```
all (x: TIMES( 4 x 12 ))
```

can be used for division. Note that Prolog acts as though arithmetical operations were database queries.

Prolog supports the list structure. Finally, to enable programs to be written in small, self-contained, testable chunks, Prolog has modules with import and export lists containing names of relations.

As an example of a Prolog program, the relations shown in listing 2 will calculate recursively the length of a list in which each element can be of any type.

The LISP program uses the conditional cond to distinguish between alternative forms of the list (i.e., an empty list or a nonempty list). In this example, rather than referring to the list symbolically by name, the two cases are represented explicitly by the *patterns* ( ) (the empty list) and (element | sublist). Instead of using a conditional, the program is expected to make the appropriate selection by *matching* the actual list against the possible patterns. In general, constructor and selector functions (in this case, ( ) and |) are used to form a set

(continued)

FP stands for functional programming and was designed by John Backus of IBM and described in his Turing Award lecture in 1977.

of patterns that distinguish between different cases pertinent to a particular problem. In English it says: The empty list has a length of zero, and the list that starts with the element x followed by the list X has the length z if the list X has the length y and z = y + 1.

FP

FP stands for "functional programming." The language was designed by John Backus of IBM and described in his Turing Award lecture in 1977. At first glance, FP shows the influence of APL in its syntax (APL without any variables).

Backus's claim is that programmers tend to manipulate data rather than functions, starting with input data and putting this through a series of functions until the required output data is reached. In the FP style of programming, primitive functions are combined in such a way as to produce a final function, the program. This is then applied to the input data to produce the output—hence, no variables are required.

FP programs map single objects onto each other; a single object is either an atom (integers or finite strings of uppercase letters) or a sequence of atoms. FP's atoms and sequences are comparable to LISP's atoms and lists. Primitive functions provided by FP include arithmetic and sequence operations, a set of predicates, and APL's iota operator for producing the first *n* integers.

The following are ways of combining functions (the *combining forms*):

1. *Composition*—written as $f \circ g$. Given two functions called f and g, $f \circ g$ is the function obtained by first applying g to the argument of the function and taking the result of this function as the argument of f.
2. *Construction*—written as $[f_1, f_2, \ldots, f_n]$. Creating a sequence of n elements whose ith element is obtained by applying f_i to the input.
3. *Conditional*—written as $p \rightarrow f;g$. If the predicate p is true, apply f to the argument; if p is false, apply g.
4. *Apply to all*—written as αf. Create a sequence of the same length as the input sequence by applying f to each element of the input data.
5. *Insert*—written as $/f$. Apply f to the sequence formed by the first element of the input data followed by $/f$ applied to the rest of the input sequence. This function is illustrated in the sample program, where f=+. A+ is inserted after the first element and between all subsequent entries.

The FP style of programming is not explicitly recursive like the other declarative languages because recursion is implicit within the combining forms.

As an example of an FP program, the following returns the length of a list:

def length = $/+ \circ \alpha \bar{1}$

This program works on a sequence in which each element can be of any type. Notice the absence of variables. In English it says: Treat each element of the sequence as a 1 and add them up.

HOPE

Hope (named after Hope Park Square, home of the University of Edinburgh's Department of Computer Science) was designed by Dave MacQueen of Bell Labs and Rod Burstall and Don Sannella of the University of Edinburgh. It is one of several *recursion-equation* languages, in which each function is represented by a set of equations that together will provide a

(continued)

result for the whole range of function arguments. A program is simply a hierarchy of these functions, together with a single invocation of the highest-level function.

Hope lets the programmer define specific or *polymorphic* data types that are checked by the compiler. Polymorphic types allow for the creation of functions that can be applied to more than one type of data (for instance, a routine that can sort numbers, characters, strings, or records). The data types num (positive integer), truval (Boolean), char, list, and set are predefined and can be used to build up more sophisticated data structures by means of type variables and data statements.

Constructor functions, defined when the data structure is defined, are associated with each structure in the normal way, but selection is done by pattern matching (as in Prolog). In the programming example in listing 3, items are selected from a list by representing the list as the pattern First::RestOfList, where First is an item and :: is the constructor that joins the item to RestOfList, which is another list.

To solve a problem using Hope, the programmer designs data structures that match the problem, produces higher-order functions (like FP's combining forms) to traverse these data structures, and then invokes the higher-order functions with arguments that represent instances for which specific results are required.

Finally, Hope has a modular structure. Thus, a programmer can implement an abstract data type (e.g., a queue) with a type declaration and a collection of functions to operate on that type. The implementation of these functions and the representation of the type itself can be hidden

Listing 3: *An example of a Hope program.*

```
dec length : list( alpha ) → num
--- length( nil ) <= 0
--- length( First :: RestOfList ) <=
1 + length( RestOfList );
```

from the user, who relies solely on the specified properties of the abstract type.

Listing 3, an example of a Hope program, computes the length of a list. This program works on a list whose elements are all of the same unspecified type. In English it says: Length is a function that takes a list of type (alpha) and returns a number. If the list is empty, the number returned is 0; otherwise, the length of the list is one more than the length of the list without the first element.

CONCLUSION

The key to the solution of some of our hardware and software problems seems to lie in incorporating referential transparency of variables into the design of declarative programming languages. This course of action appears to improve the coupling between compilable source code and the abstractions of a specification language, to make the code amenable to direct mathematical verification, to open up a way to perform true parallel processing, to bring code and data conceptually closer together, and to permit the implementation of polymorphic abstract data types. ■

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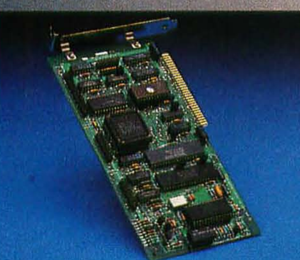
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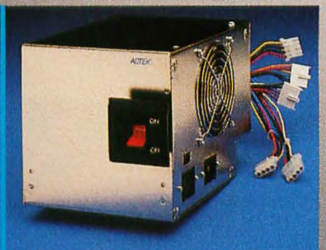
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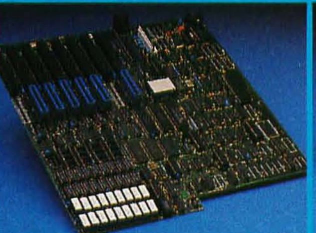

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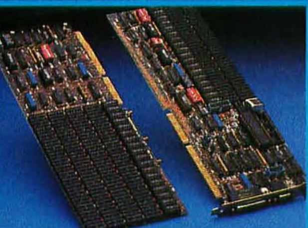
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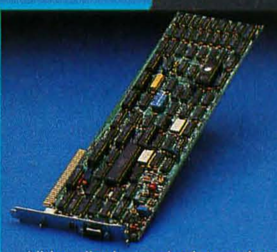


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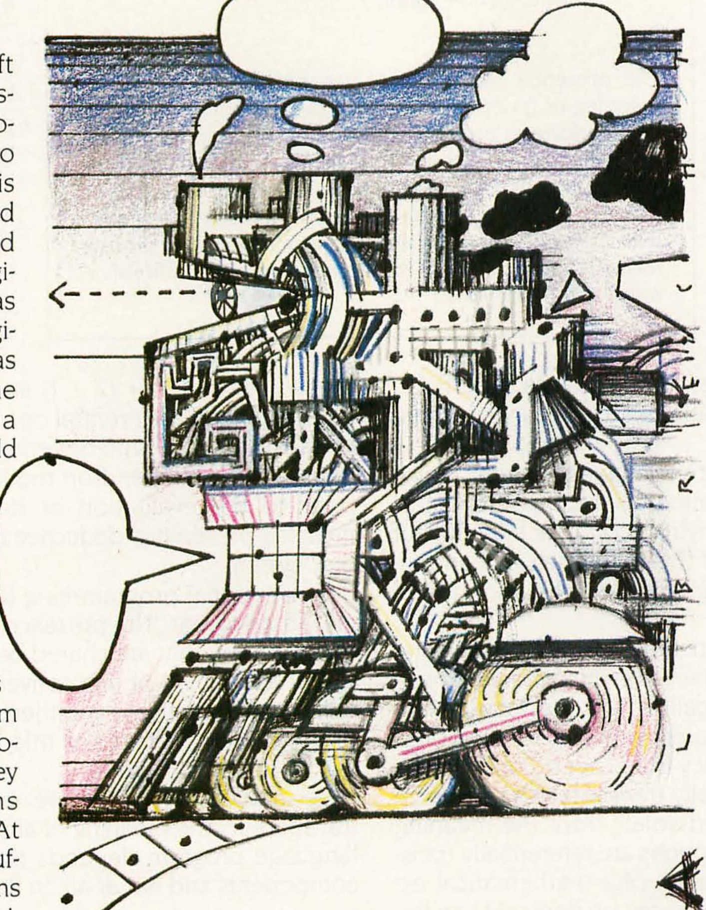
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PROGRAM TRANSFORMATION

BY JOHN DARLINGTON

A *program-development methodology explained*



IS PROGRAMMING a craft or a science? Most professional (and amateur) programmers would like to claim that what they do is scientific, but compared with the standards attained in other, more mature engineering disciplines such as aeronautical or civil engineering, programming has a long way to go. If one were asked to build a bridge, I doubt that it would be acceptable to construct an initial version, try it out, and, when it fell down, correct the mistakes made in the design, and then repeat the process until the bridge stayed up. This is, however, the paradigm that most practicing programmers follow as they debug their programs toward a working state. At present, programming suffers from a lack of notations for building models or initial specifications of systems and of any criteria for judging the correctness of solutions to such specifications.

As the cost of hardware decreases, the proportion of the cost of any total system that is attributable to software becomes larger. If it is difficult enough to develop complex software in the first place, the problems get even worse if one wishes to maintain or enhance an existing complex software system.

Advances have been

(continued)

John Darlington is a professor of programming methodology at the Department of Computing, Imperial College (180 Queen's Gate, London SW7 2BZ, England). Dr. Darlington is the head of a research group at Imperial College that concentrates on program transformation, functional languages, and parallel architectures.

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made toward solving this problem. The invention of the first high-level languages, such as FORTRAN, represented a significant advance over the use of machine code and improved programmer productivity tenfold. It is a pity that not many other quantum leaps have been made on the software side. Modern high-level languages do not differ radically from FORTRAN. Structured programming, the white hope of the sixties and seventies, has demonstrably failed to provide the final solution.

All these developments, from new languages to fancy editors and other utilities, seem to be of a kind that, although they will undoubtedly increase programmers' output (often not always of correct code), are incapable of enabling programming to make the transition from an inexact to an exact science. Our goal should be the precision of mathematics. No one feels the need to debug a mathematical theorem or relies on laws that are probably correct apart from a few residual bugs. Programs are superficially similar to mathematical notations, so why can't we share their degree of certainty?

The proponents of declarative languages claim that it is possible to make programming an exact mathematical science with all the accompanying economic benefits but that a necessary condition for this to happen is abandonment of the conventional languages and the adoption of declarative ones.

There is a fundamental distinction between the declarative languages and conventional (or even unconventional) procedural ones such as Pascal or LISP. Declarative languages are referentially transparent, while procedural ones are not. Referential transparency is a property of language systems. A system is referentially transparent if the meaning of a whole can be derived solely from the meaning of its parts. All mathematical notions are referentially transparent. Thus the meaning (value) of a mathematical expression such as (3 + 2) * (2 + 1) can be derived from the meaning of its components. Thus 3 + 2 has value 5 and 2 + 1 has value 3. Knowing these, we can derive the meaning of the whole expression, 15.

A consequence of this property is that there is a simple substitutive equality relation between expressions in any referentially transparent system. Expressions that have the same meaning can be freely substituted for one another in any context without changing the meaning of the whole. Thus, since 3 + 2 and 4 + 1 have the same meaning (5), 4 + 1 can be substituted for 3 + 2 in (3 + 2) * (2 + 1), giving (4 + 1) * (2 + 1). It is the possession of this property that makes mathematics an exact deductive science.

Laws can be developed that allow the formal (syntactic) manipulation of expressions and are guaranteed to preserve the meaning of the expressions being manipulated. The distributive law of arithmetic, (x + y) * z = (x * z) + (y * z), is an example of such a law. Using this, we can convert (4 + 1) * (2 + 1) to 4 * (2 + 1) + 1 * (2 + 1) and know that the meaning is not changed. Referential opacity means that a system's behavior may be time-dependent; i.e., the meaning of a fragment may depend on the history of what happened prior to the evaluation of that fragment. No simple, meaning-preserving, deductive rules can be developed for that system.

Conventional programming languages are not referentially transparent. The presence of assignment statements and variables that are shared between procedures means that the meaning of any conventional program is potentially time-dependent and there is no simple substitution property. See the text box titled "A Referentially Opaque Pascal Program" above.

Declarative languages are, by definition, referentially transparent. The meaning of any fragment of a declarative language program depends only on the meaning of its components and not at all on the history of any computa-

(continued)

A Referentially Opaque Pascal Program

The following program fragment illustrates how the behavior of a Pascal program can be history-sensitive.

```
var switch:boolean;
begin
        switch: = false;

        function f(n:integer) : integer;
        begin
        switch: = true;
        f: = 2*n
        end;

        function g(n:integer):integer;
        begin
        if switch then g: = 3*n else g: = 4*n
        end;

        writeln(g(2) + f(1));
        writeln(f(1) + g(2));
end;
```

The presence of the global variable switch makes the meaning of g dependent on the history of the computation performed prior to its evaluation. Therefore, g(2) + f(1) evaluates to 10, but f(1) + g(2) evaluates to 8. Thus, commutativity, one of the simplest manipulation laws (namely, X+Y = Y+X) does not apply to Pascal programs. [*Editor's note: This is a standard computer science usage of the term referential opacity. It should not be confused with the mathematical notion of the same name.*]

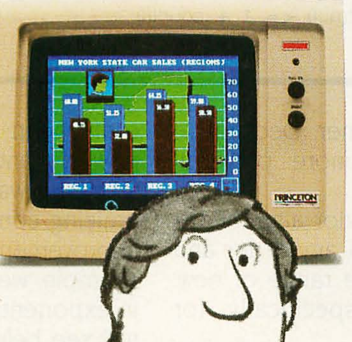
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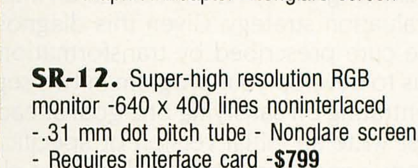
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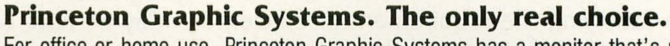
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tion performed prior to the evaluation of that fragment. From this simple distinction many benefits flow.

The absence of any time-dependent behavior implies that declarative programs are easier to write and understand. Many burdens concerned with organizing or comprehending the sequencing of events are removed from the programmer. Declarative languages are therefore intrinsically more powerful descriptive notations.

The absence of time-dependent behavior also means that subexpressions can be evaluated in any order and therefore in parallel, leading to a whole range of new, highly parallel machines designed specifically for declarative languages.

From the software-development viewpoint, the critical advantage referential transparency brings to the declarative languages is the ease with which formal manipulation systems can be developed for declarative programs.

The existence of such manipulation systems makes the process of program development by program transformation feasible in the declarative languages. The ideas behind program transformation stem from a diagnosis that many of the difficulties met in developing programs arise from trying to satisfy two often conflicting goals simultaneously. A program must be correct; that is, it must meet its specification and be free of bugs. A program must also be efficient: It must compute the required results in a reasonable time and make minimal use of resources. The first goal is best met by making a program as clear and obvious as possible. Meeting the second often involves sacrificing clarity for the sake of an intricate, but efficient, evaluation strategy. Given this diagnosis of the disease, the cure prescribed by transformation is fairly obvious. It is to develop your program in two separate stages, concentrating on satisfying one goal at each stage. Thus, you first write an initial version or specification of your program, concentrating on making it as clear and obviously correct as possible. Only when you are satisfied that you have a correct and complete initial version do you turn your attention to satisfying the requirement of efficient execution. This is achieved by successively manipulating or transforming the program into more and more efficient versions. It is crucial that the manipulations performed do not change the meaning of the program. Thus, to be successful, transformation depends on the existence of a set of manipulation rules capable of improving performance but guaranteed to preserve the meaning of a program. It is the availability of such manipulation rules that makes transformation feasible in declarative languages and very difficult in procedural ones.

Note that the initial specification is itself a program. As we will see later, if one really puts one's mind to it, one can write such wonderfully inefficient programs that it is straining the meaning somewhat to call them executable! But that is the whole point. By maximizing the clarity and obviousness of the initial version, one is making it much more likely to be correct. It does, however, mean that the transformations have to be pretty powerful and capable of achieving improvements in performance way beyond that achievable by conventional optimizing compilers. Characteristically, one is looking for improvements in the order of the program's efficiency. For example, we want to transform algorithms that compute in exponential time to linear or logarithmic ones. As we will see below, such improvements are possible.

The design of optimizing compilers for conventional languages, such as FORTRAN or Pascal, has developed to a fine art. Some of the optimizations these compilers perform, such as strength reduction or code lifting, can be expressed as source-to-source manipulations and are therefore strictly program transformations. However, the sort of transformations we are seeking can be characterized as ones that can cause changes of nature, not just changes of degree. Only in rare, pathological cases are optimizing compilers capable of producing as output a program recognizably different from their input. We need to be able to do this routinely.

The second consequence of having specifications that are executable as programs is that they can be exercised and tested against the informal requirements or modified to meet changing requirements. Thus, a process of rapid prototyping is possible.

A Simple Transformation

Let us now look at a transformation. The example I have chosen to start with is fairly trivial and will not require large improvements in efficiency. Nevertheless, it will serve to introduce the transformations used and illustrate that simple manipulations can produce significantly altered programs.

Say we have been asked to find the average of a list of numbers. The textbook definition of average is the sum of all the numbers divided by how many of them there are. If we take this as the basis for our obviously correct initial program, in Hope we get something of the form shown in listing 1.

Listing 1: *An inefficient Hope program for calculating the average of a list of numbers.*

```
dec average,sum,count:list(num) -> num;
--- average(l) <= sum(l) div count(l);    (A)
--- sum(nil) <= 0;                         (B)
--- sum(n::l) <= n + sum(l);               (C)
--- count(nil) <= 0;                       (D)
--- count(n::l) <= 1 + count(l);           (E)
```

This program is clearly correct, but on a sequential machine involves the slight inefficiency that the list is traversed twice. Any self-respecting Pascal programmer would collect both the sum and the count on one pass over the list.

(continued)

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Let us derive such a program in Hope by systematic manipulation of the original one. We will present the transformations in an informal manner. Each step will take a set of equations, i.e., a program, and produce new equations. Informally, we hope that it will be obvious that all the new equations are consequences of the existing equations and thus cannot change the meaning of the program as a whole. Formally, all our transformations will use rules from the unfold/fold transformation system (see the text box below).

The first step in our transformation is to introduce a definition for a new function, av.

```
dec av:list(num) -> num x num;
--- av(l) <= (sum(l), count(l));                    (1)
```

For correctness, the only thing we have to concern ourselves with is that introducing this new definition cannot change the meaning of our program. As av is not mentioned at all in the previous equations, this is clearly true. Why we introduced this particular definition is another question. The situation is analogous to the use of constructions in geometry. Introducing the right construction assists proofs to be carried out and can never enable anything false to be proved. Where the idea for the right construction comes from in the first place is more mysterious.

The formal reading of an equation such as --- av(l) <= (sum(l), count(l)); is that the expression on the left-hand side, av(l), is equal to the expression on the right-hand side, (sum(l), count(l)), for all values of l. If the equation is true for all l it is true for some particular instance of l. Thus we can instantiate this equation by setting l to nil, getting the equation

```
--- av(nil) <= (sum(nil), count(nil));              (2)
```

Statement (2) is obviously a consequence of statement (1) and so cannot alter meaning. But statements (B) and (D) in listing 1 give values for sum(nil) and count(nil), allowing us to deduce

```
--- av(nil) <= (0, 0);                              (3)
```

which, as well as being true about av, begins to look like part of a program for av.

Returning to statement (1) and this time instantiating l to x::l we get

```
--- av(x::l) <= (sum(x::l), count(x::l));           (4)
```

Statements (C) and (E) allow us to deduce

```
--- av(x::l) <= (x + sum(l), 1 + count(l));         (5)
```

But we can rearrange this using the Hope where construct to

```
--- av(x::l) <= (x + u, 1 + v)
               where (u,v) == (sum(l), count(l));   (6)
```

Now we see that (sum(l), count(l)) appears as the right-hand side. But this is the right-hand side of (A). What's more, it is equal to the left-hand side of (A), av(l). Because of referential transparency, the <= can be read as =. Thus, we can replace (sum(l), count(l)) by av(l), getting

```
--- av(x::l) <= (x + u, 1 + v)
               where (u, v) == av(l);               (7)
```

Statements (3) and (7) now constitute an efficient program for av but do not at the moment help us with average. Returning to (A), we get

```
--- average(l) <= u div v
                  where(u,v) == (sum(l), count(l));
```

and thus

```
--- average(l) <= u div v
                  where (u, v) == av(l);
```

Collecting the useful equations together, we get a new program for average (see listing 2).

This final program, we would claim, is not so obviously correct as our initial version but is more efficient in that only one pass is performed over the list. The crucial point

The Unfold/Fold Transformation System

The unfold/fold system consists of six rules that allow new equations to be introduced that are consequences of existing equations.

1. Definition. Introduce a new recursion equation whose left-hand expression is not an instance of the left-hand expression of any previous equation.
2. Instantiation. Introduce a substitution instance of an existing equation.
3. Unfolding. If E<=E' and F<=F' are equations and there is some occurrence in F' of an instance of E, replace it by the corresponding instance of E' obtaining F", then add the equation F<=F".
4. Folding. If E<=E' and F<=F' are equations and there is some occurrence in F' of an instance of E', replace it by the corresponding instance of E obtaining F", then add the equation F<=F".
5. Abstraction. We may introduce a where clause by deriving from a previous equation E<=E' a new equation:

```
E<=E' [u1/F1, . . . ,un/Fn]
      where (u1, . . . ,un) == (F1, . . . ,Fn)
```

(E[E1/E2] means E with all occurrences of subexpressions E2 replaced by E1.)

6. Laws. We may transform an equation by using on its right-hand expression any laws we have about the primitives (associativity, commutativity, etc.) obtaining a new equation.

is that there is no need to conduct a separate proof to show that the final program is equivalent to the initial one. It is correct by construction. Neither do we have to conduct proofs to show the intermediate steps are legitimate. The correct application of the rules can be checked syntactically (and therefore mechanically).

The above example illustrated the transformation techniques but only achieved a moderate increase in performance. To give credence to our claim that transformation can achieve substantial performance increases, let us quickly look at a classic transformation, the conversion of the exponential definition of the Fibonacci function to a linear version, i.e., converting a definition that takes 2^n steps to compute fib(n) to one that takes n steps (see listing 3). Here the improvement in performance is much greater, but the similarity between this and the previous transformation is appealing. Our pulling the correct definitions out of a hat may be slightly off-putting, but their origin is not quite as mysterious as it seems. They can be systematically derived by investigating the pattern of computation of the specification program and identifying repeated, and therefore unnecessary, computations.

Listing 2: A *more efficient* Hope *program for calculating numerical averages, generated by transformation of listing* 1.

```
dec average:list(num) -> num;
dec av:list(num) -> num x num;

--- average(l) <= u div v
                          where (u, v) == av(l);

--- av(nil) <= (0, 0);
--- av(x::l) <= (x+u, 1+u)
                          where (u, v) == av(l);
```

Listing 3: A *transformation of an exponential-time Fibonacci function program to a linear-time program.*

```
Initial Program
      dec fib:num -> num;

      --- fib(0) <= 1;
      --- fib(1) <= 1;
      --- fib(succ(succ(n))) <= fib(n+1) + fib(n);

Transformation
      dec g:num -> num x num;
      --- g(n) <= (fib(n+1), fib(n));           Definition
      --- g(0) <= (fib(1), fib(0));             Instantiation
               <= (1, 1);                               Unfold
      --- g(succ(n)) <= (fib(n+2), fib(n+1));   Instantiation
                     <= (fib(n+1) + fib(n), fib(n+1)); Unfold
                     <= (u+v, u)
                        where (u, v) == (fib(n+1), fib(n));
                                                      Abstract
                     <= (u+v, u)
                        where (u, v) == g(n)           Fold
      --- fib(succ(succ(n)))
                     <= u+v
                        where (u, v) == (fib(n+1), fib(n));
                                                      Abstract
                     <= u+v
                        where (u,v) == g(n);           Fold

Final Program
      dec fib:num -> num;
      dec g:num -> num x num

      --- fib(0) <= 1;
      --- fib(1) <= 1;
      --- fib(succ(succ(n))) <= u + v
                              where (u,v) == g(n);
      --- g(o) <= (1, 1);
      --- g(succ(n)) <= (u+v, u)
                        where (u, v) == g(n);
```

Practicality and Usefulness of Transformation

If we are proposing, as we are, that transformation can place software development and programming onto a new plateau of scientific rigor, we must evaluate its potential very severely. To be ultimately useful, any transformation methodology must satisfy three criteria. First, it must be correct, that is, meaning-preserving. Second, it must be adequate or complete, so that all desired program developments can be achieved using the methodology. Finally, it must be expressive enough that, not only can all developments be expressed, but they can be expressed in an intelligible and communicable manner. Let us see how functional languages and the unfold/fold methodology being proposed here meet these criteria.

Correctness

It is, of course, crucial that any system used for transformation preserve meaning. This property has been shown to hold for the unfold/fold system. There is one thing to watch out for in doing transformations, however. It is possible, using the unfold/fold system, to produce a program that will fail to terminate, using input values for which the original specification program will terminate. Happily, there are simple guidelines that ensure that the system can be used without fear of introducing nontermination. See the text box "Correctness and Completeness of the Unfold/Fold System" on page 210.

Completeness

The other question that needs to be asked of any transformation system is: How adequate or complete is it? Can any transformation that you would like to achieve be expressed using only rules from the system? The answer for the unfold/fold system is theoretically no but practically yes. There are some pathological examples of pairs of (functional) programs that are demonstrably equivalent

(continued)

but which cannot be transformed one to the other without stepping outside the strict confines of the system. A simple example of this is contained in the "Correctness and Completeness" text box. However, much work based on the unfold/fold system has demonstrated its practicality and wide range of applicability.

The repertoire of the types of transformational operations that can be expressed by utilizing the unfold/fold system is quite impressive. It includes the following:

Listing 4a: A *recursive definition of factorial in Hope.*

```
dec fact:num -> num;
--- fact(0) <= 1;
--- fact(succ(n)) <= (n+1) * fact(n);
```

Listing 4b: A *linear definition of factorial in Hope.*

```
dec fact:num -> num;
dec factit:num x num -> num;
--- fact(n) <= factit(n, 1);
--- factit(0, acc) <= acc;
--- factit(succ(n), acc) <= factit(n, (n+1) * acc);
```

LOOP COMBINATIONS: The essence of the average example is that there are two computationally independent loops that needed to be combined for efficiency. Many transformations are instances of this type of transformation.

RECURSION REMOVAL: Using transformation it is possible to convert fully recursive definitions such as listing 4a to linear forms such as listing 4b. The important point about the latter definition is that it can be executed without using a run-time stack and can be simply converted to a program using only a while loop in a language such as Pascal. The early work on transformation viewed the functional program as an initial specification and aimed at a program in an imperative language as the final output. With the development of efficient implementations for functional languages and the imminent arrival of specially designed parallel machines, this aspect of the transformation work has tended to become less important.

ABSTRACT DATA TYPES: One of the more impressive applications of the basic transformation methodology has been the work on the systematic derivation of implementations for abstract data types. In order to support abstract data types such as trees or priority queues in an imperative language such as Pascal, one has to write a lot of code providing implementations for the access functions of the abstract type in terms of the primitives of the concrete types provided in the language. This often results in an inefficient final program that is cumbersome and difficult to maintain or move to other implementation bases. Work based on functional languages and transformation has shown how efficient implementations can be automatically synthesized from a specification of the abstract and concrete types and a single mapping function formalizing how the concrete type is to be used to represent the abstract one.

PROGRAM SYNTHESIS: As we shall see below, in a functional language we are able to write specifications that define a program more by properties it must satisfy rather than by a computational recipe, however inefficient, for its evaluation. Such specifications can also be converted to efficient programs, but we should perhaps talk more of program synthesis rather than program transformation. The crucial point is that both specification and program are still expressed using the same notation. There is no discontinuity between forms of expression that are specifications and forms of expression that are programs.

TRANSFORMATION FOR PARALLEL EVALUATION: Early work on transformation concentrated on producing programs that would run efficiently on conventional sequential machines. For a parallel machine, different program forms are needed for efficient execution. Happily, exactly the same transformation methodology enables us to produce these forms as enables us to produce efficient sequential ones.

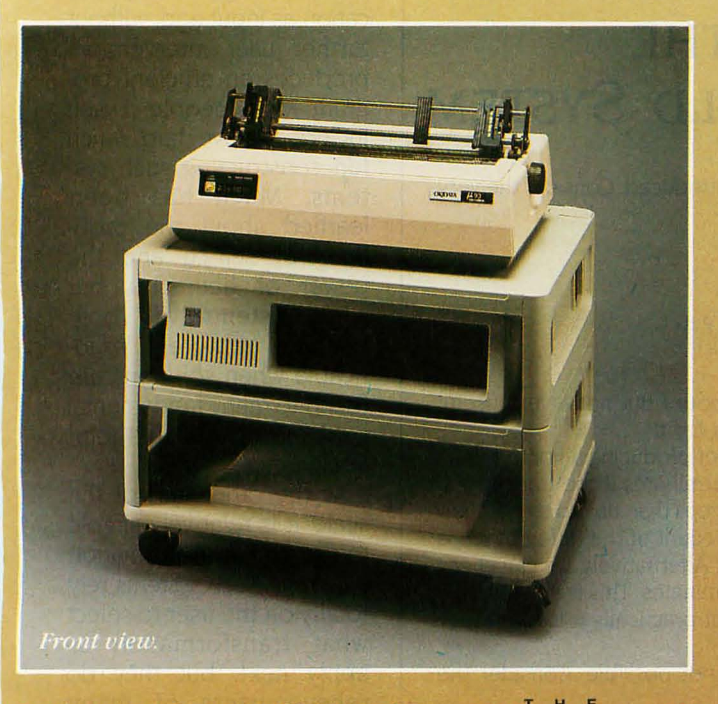
Among the significant transformational developments studied by transformation workers are sorting algorithms, compilers, parsing algorithms, text formatters, editors, operating systems, and numerical algorithm libraries. Particular academic interest has been shown in analyzing the relationships between different algorithms for a particular task, such as sorting, by systematically synthesizing all the algorithms in the class from a common very high level specification. Studies of algorithms for sorting, parsing, and searching have exposed pleasing symmetries and relationships between algorithms previously considered unrelated.

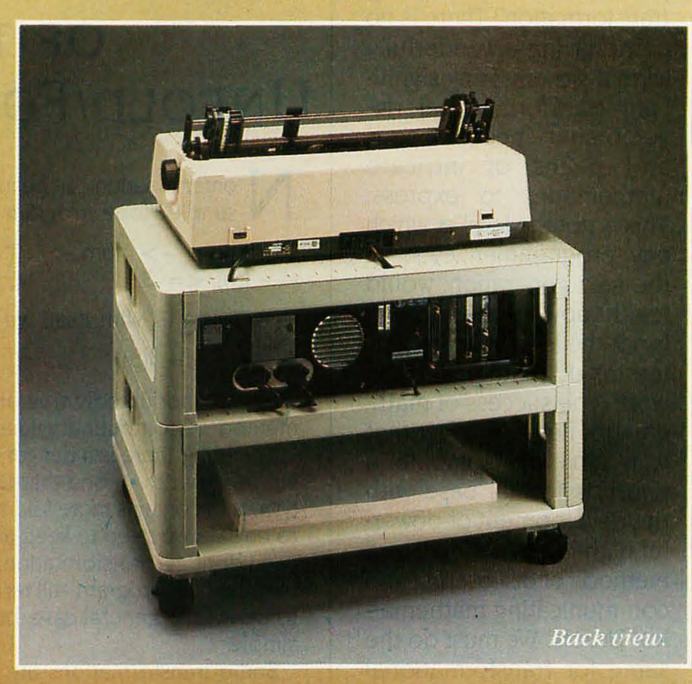
It would be misleading to give the impression that work has reached the stage whereby any program development, however large or complex, can be easily expressed using transformation, and even more misleading to imply that the whole process is about to be mechanized and programmers are about to become redundant. What we would claim is that transformation offers the possibility that programming can progress from an art to a science and that even this possibility is precluded if one continues with the conventional languages. Furthermore, sufficient progress is being made on extending the practicality of transformation techniques, particularly in the area of partial mechanization, that we can feel optimistic about the prospects of achieving a mechanical realization of program optimization and proof in the future.

(continued)

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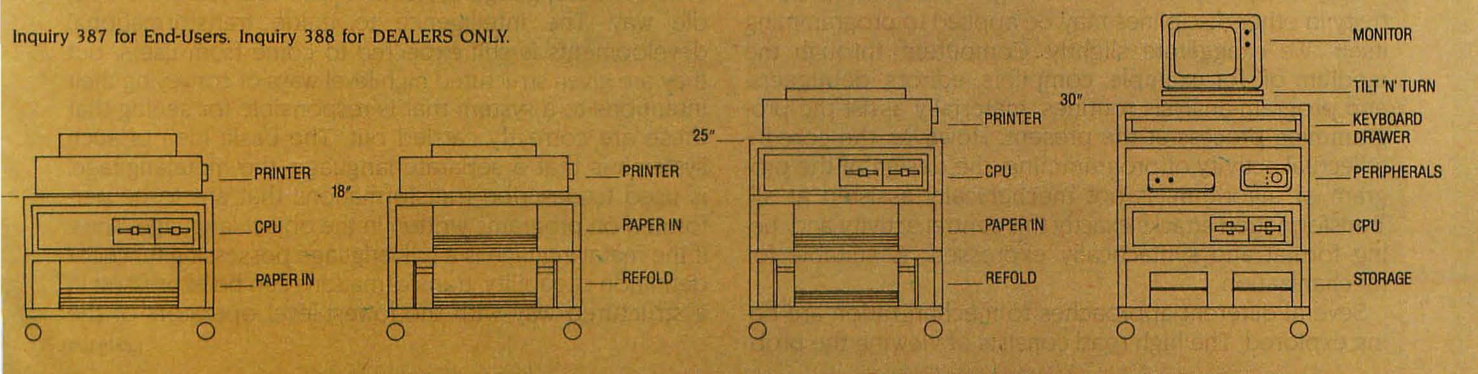
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EXPRESSIBILITY

The final parameter governing transformation's ultimate usefulness is: How expressive can we be using transformation? There is no point having a wonderfully formal system if any significant transformational development needs pages and pages of intricate mathematics to express. This is not the level at which any programmer, even of the next generation, would feel happy. Furthermore, it is not the level at which professional mathematicians work. The success of mathematics lies in the fact that it is able to combine a rigorous formal base with the development of powerful high-level concepts and methods of discovering and communicating mathematical proofs. We must do the same for transformational programming.

The concept of expressibility and intelligibility is intimately tied up with the prospects for mechanization, which we see as the ultimate payoff for program transformation. Do not be alarmed. We are not predicting the demise of the programmer or promising fully automatic programming systems. Rather, we are intimating that some time in the not-too-distant future the power and accuracy that computers have brought to bear on productivity in other disciplines may be applied to programming itself. We exaggerate slightly. Computers, through the medium of, for example, compilers, editors, debuggers, and program-analysis routines, materially assist the programming process at the present. However, the core intellectual activity of programming, the design of the program or algorithm, is not mechanically assisted at all. Transformation attacks exactly this central activity and, being formal and syntactically expressed, is suitable for mechanization.

Several different approaches to mechanization are being explored. The high road consists of viewing the problem as a problem in artificial intelligence and attempting to construct a fully automatic system that accepts a high-level specification as input and, without further user intervention, produces an efficient program. Many people, myself included, have had much fun constructing such systems. Much has been learned about the problems of search and the power of heuristics, but such systems will only become remotely practicable when solutions are found to many fundamental problems in artificial intelligence.

At the other end of the scale, it is relatively simple to construct transformation checkers. Such systems rely totally on the user to select what transformation to apply next, but they do relieve users of many clerical burdens and ensure that the transformations are correctly applied. The problem is that, for any moderate-size transformational development, the number of steps needed, if all the steps are at the level of the fundamental rules of the system, becomes inordinate and difficult to comprehend.

The most promising medium-term prospect lies in the development of so-called metalanguage systems. These represent the middle way. The intelligence to guide transformational developments is still expected to come from users, but they are given structured high-level ways of conveying their intentions to a system that is responsible for seeing that these are correctly carried out. The basic idea of such systems is that a separate language, the metalanguage, is used to describe transformations that are to be performed on programs written in the object language. Thus, if the metalanguage is a full language possessing function-definition capability, transformations can be expressed in a structured way with the lowest-level operators of the

(continued)

CORRECTNESS AND COMPLETENESS OF THE UNFOLD/FOLD SYSTEM

Nontermination can be introduced. Consider the very simple Hope program

```
dec f:num -> num;
--- f(n) <= 3;
```

If we fold this with itself we get

```
--- f(n) <= f(n);
```

which is undoubtedly true about f but not a very useful method of computing values for f!

Generally, there is a danger of producing a nonterminating program from one that terminates if the transformation used contains more fold steps than unfold steps. Thus, to be safe we need to keep a count of the different steps used during a transformation. Alternatively, we can check that the final program still terminates. This is not possible to do for the general case, but practically it is often very simple.

Some transformations are not possible. Consider the functions f1 and f2:

```
dec f1:num -> num'
--- f1(0) <= 0;
--- f1(succ(n)) <= 1 + f1(n);

dec f2: num -> num;
--- f2(n) <= n;
```

f1 and f2 are obviously equivalent and f2 can be transformed to f1, but f1 cannot be transformed to f2, which is the direction we would like to go. The problem is that f2 has no recursion at all on the right-hand side and so cannot be produced using a fold step. To derive f2, we would have to guess its definition and then prove equivalence. Happily, realistically sized programs never have this problem.



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metalanguage corresponding to the guaranteed meaning-preserving operations and the higher-level, more meaningful operations being constructed out of these.

In our work at Imperial College, we have developed a system for transforming Hope programs that also uses Hope as the metalanguage. Thus, the six rules of the unfold/fold system become Hope (metalanguage) functions that operate on Hope (object) programs represented as Hope data structures. Out of these primitive operations, more powerful transformation operators can be built using the normal function-definition capability. The trick is to ensure that these defined operators inherit the correctness-preserving nature of the basic operations. In Hope, this is achieved using the module and typing mechanisms. The Hope data type used to represent Hope object programs, together with the basic operators, are formed into a module from which only the correctness-preserving operators are exported. These operators are the only way programs can be altered. Thus, the system designer or user is free to define any new operation in terms of the ones provided, secure in the knowledge that there is no way he or she can conspire to produce an incorrect program.

A range of meaningful second-level operations can be identified, corresponding to transformation operations such as combine loops, remove recursion, and implement one data type in another. Each tactic involves a limited search to try to express the requested transformation in terms of the lower-level primitives. Each tactic either succeeds, returning the altered program, or fails, indicating either that the requested transformation is impossible or that the tactic failed to find it. There is no way an incorrect program can be produced.

Thus, a transformation plan emerges as a structured Hope metalanguage program that is understandable, communicable, and machine-checkable. The Hope metalanguage program in a real sense provides a formal and precise notation in which to express the design of a program. This, we feel, has important consequences not only for initial program development, but also for program modification and maintenance.

If, after a program has been successfully developed, the specification from which it was derived is retained along with the metalanguage program, then any subsequent modifications or enhancements can be performed on the specification. Because of the nature of specifications, this

(continued)

should result in fewer errors being introduced than is normally the case when complex executable code is modified. The old metalanguage program can then be applied to the new specification. It is to be hoped that, as the metalanguage program encapsulates the higher-level ideas behind the design of the program, it will still be applicable to the modified specification. If it is, then no further work has to be done. If not, the worst that can happen is that the system fails to produce an acceptably efficient program from the specification. This is an indication that the modifications made are substantial enough to require a rethink on our design ideas, and these can be expressed as modifications to the metalanguage program necessary to achieve a successful transformation.

SPECIFICATION TECHNIQUES

The essence of a specification is to say what is to be computed, not how it is to be computed. The area of specification techniques deserves an article to itself. Here, I will confine myself to giving a few simple examples to illustrate the directions in which the work is leading.

In a functional language, the forms that one can write are restricted to facilitate the construction of efficient interpreters. One route to languages of greater expressive power for use in specification is to remove some of these restrictions. For example, what we can write on the left-hand sides of equations in Hope is severely limited. If we remove some of these restrictions, we can write equations that define functions implicitly rather than explicitly.

For example, given that integer multiplication is defined as the Hope function mult, one could simply define the division function, div, thus:

```
mult(div(n, m), m) = n
```

Such a specification can be transformed to a directly executable version using the standard manipulation rules. It is interesting to note that such specifications can also be executed but require more sophisticated, and less efficient, interpretation regimes than are currently used for functional languages.

Another line of development for specification is specialized, often tabular, specification languages for specific domains. One route to such languages is to regard them as syntactic extensions to an underlying functional language and use transformation techniques to convert them to efficiently executable programs.

OTHER LANGUAGES, OTHER TOOLS

Transformation is a general technique and has been applied to many styles of language other than the functional ones. Transformation techniques and systems based on conventional procedural languages have been extensively studied. It will come as no surprise to the reader to learn that we have doubts about the ultimate success of these enterprises.

In contrast, transformation techniques have been very

(continued)

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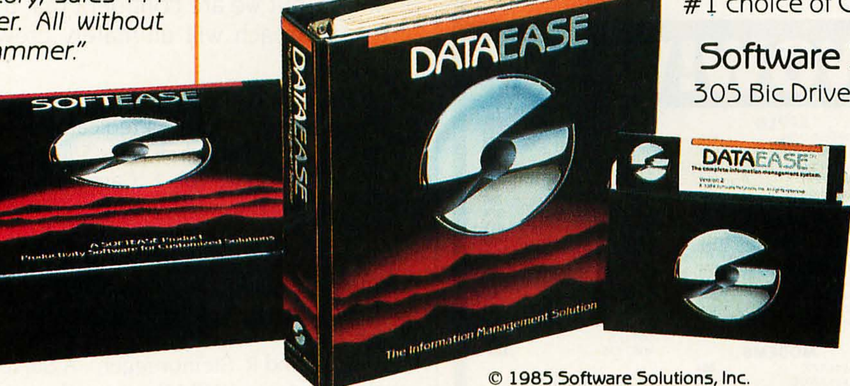
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successfully applied to the other main class of declarative languages, the logic programming ones. The unfold/fold methodology can be directly translated into logic programming terms and all the same derivations performed on logic programs as can be performed on functional ones. Furthermore, one can use the full descriptive capability of unrestricted first-order predicate calculus for a specification language and transform these specifications into efficient Horn clause logic programs.

The mathematical well-foundedness of the declarative languages allows the construction of other useful tools besides transformation systems. For example, one can analyze functional and logic programs to assess their efficiency, check their consistency, and also derive consequences from programs. For example, we may be able to infer that the result of a computation can never be greater than some bound.

Our vision for a programming environment of the future is one founded on machine-assisted transformation as the main program-development activity, but supported by a collection of intelligent programming tools that offer material assistance to the programmer because they understand the developing program at a level much deeper than the textual level at which most present-day program-support tools operate.

FUTURE PROSPECTS

Transformation is a promise for the future, not a present-day practical reality. However, the current problems and costs associated with the development and maintenance of large-scale, complex software systems seems to point to a need for some radical solution that is not accessible via present-day languages and methodologies.

The next few years promise to be fascinating ones for workers in declarative languages. The coming together of parallel machines, mature declarative languages, and transformation-based programming environments means that all the mutually supporting components are in place for a searching appraisal of the ultimate practicality of this approach. Much needs to be done to deliver on all the promises, but we are confident that the well-foundedness of the approach will ultimately prevail. ■

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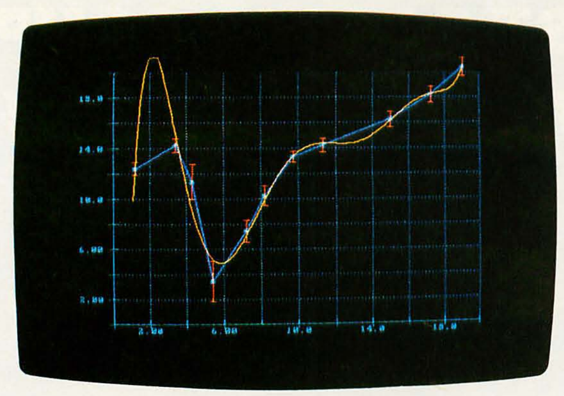
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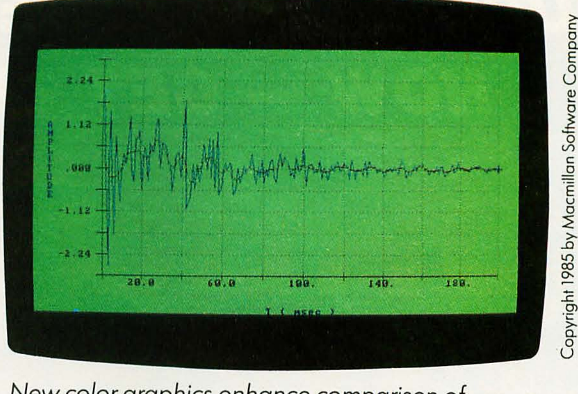
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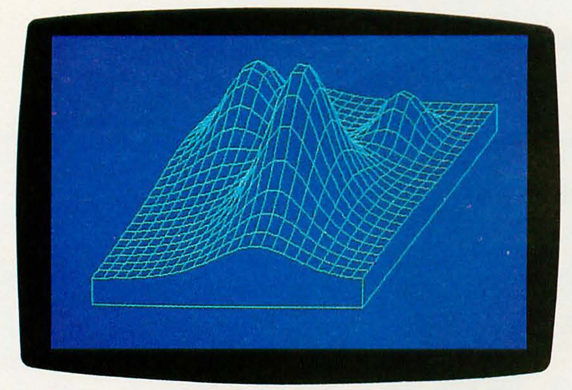
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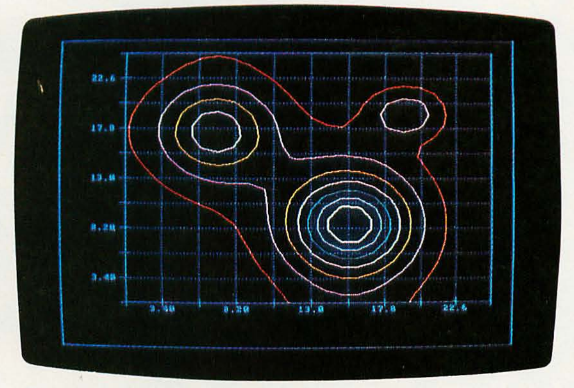
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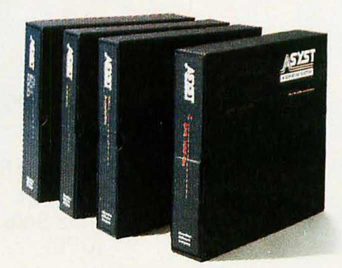
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FUNCTIONAL PROGRAMMING USING FP

BY PETER G. HARRISON AND HESSAM KHOSHNEVISAN

How to program without objects

IN 1977, JOHN BACKUS introduced a functional style of programming in which variable-free programs are built from a set of primitive programs by a small set of combining forms (functionals that are also often referred to as program-forming operations or PFOs) and by recursive definitions. This style is embodied in the language FP, which facilitates the manipulation of the functions themselves rather than repeatedly creating new objects from old ones in an auxiliary domain. FP thus relates to a higher level of analysis than do the more common, object-oriented functional languages. In fact, FP has its own functional algebra that prescribes rules for manipulation of functions and so simplifies reasoning about programs. FP systems have the following properties:

• Programs have extremely simple semantics.
• There often exist nonrecursive expressions for many functions that are normally recursively defined (similar to using a loop in Pascal).
• Programs exhibit a clear hierarchical structure.
• The principal combining forms are the operations of the powerful algebra of FP programs. This algebra can be used to solve equations for recursively defined programs and to transform programs into versions that run more efficiently or consume less space.
• Transformation of recursive to nonrecursive functions and to loops can often be achieved automatically in FP.

The main obstacle to the advancement of functional programming languages has been their poor run-time performance on conventional computers. This is primarily due to the large number of (mainly stack-based) manipulations required to preserve referential transparency in the languages. Von Neumann computers execute instructions sequentially and so are tailored toward supporting sequential languages with destructive assignment. One way to improve performance is to offer a radically different computer architecture, specifically tailored toward supporting functional languages (see references 1 and 2). But there is also a need to provide efficient implementations of these languages on conventional machines. These are likely to remain widespread for the foreseeable future, in particular in the personal computer market, whatever the impact of any new architectures. A route to improved performance is to transform recursively defined solutions into iterative ones. FP programs lend themselves to this type of transformation very well since they do not refer to the auxiliary domain of objects, which often obscures the process of program transformation. Transformations of this sort may also prove beneficial to parallel implementations by increasing the size of the basic unit of work performed by each processor. This naturally reduces communication overhead, which often limits the performance of parallel machines.

(continued)

Dr. Peter G. Harrison is a lecturer in the Department of Computing, Imperial College. Hessam Khoshnevisan received his bachelor's degree in computing science from Imperial College, where he now works as a research assistant on the ALICE project. They can be reached at Imperial College, 180 Queen's Gate, London SW7 2BZ, England.

The FP algebra provides a formal basis for program transformation and so facilitates its automation. [*Editor's note: The idea of program transformation is discussed in "Program Transformation" by John Darlington on page* 201.] Conventional transformation techniques prescribe algorithms for transforming functions when applied to certain arguments. The transformation strategy in FP is based upon theorems that state identities between functional expressions. A transformation is then simply an instance of the application of a theorem.

FP SYSTEMS

An FP system consists of the following:

- A set of primitive functions (for example, the arithmetic operators +, −, *, etc.).
- A set of PFOs. These are programming constructs analogous to while loops, conditionals, and so on, found in conventional languages like Pascal, and they may be used to create more complex functions from simpler ones.
- A domain of objects that might be, for example, integers, characters, sequences, etc.

User-defined functions are defined in terms of these FP system components.

PFOs are the programming constructs of FP (like while, if. . .then. . .else, etc., of Pascal) and differ from the programming constructs of other languages (including other functional languages) in that they are predefined operations on functions as opposed to objects. We are all familiar with the conditional statements, such as if P then Q else R in Pascal. The conditional operation of FP (f → g ; h) is similar except that the predicate and the true and false branches of the conditional are expressions involving only functions, namely f, g, and h. These expressions can be primitive functions, user-defined functions, or expressions built using the PFOs. In short, all PFOs take a number of functions as arguments and return a single FP function. All FP functions take a single object as input and produce a single object as their result; i.e., they are of type Object −> Object. All FP systems are equipped with an operation called application, which, given a function and an object, produces the result of applying the function to the object. The notation f:x is used to represent the application of function f to the object x.

To define an FP system, we must specify the set of primitive functions, the set of PFOs, and the set of objects. Listed in the text box "FP Syntax" on page 228 are some examples of primitives and PFOs that might be present in an FP system. The meaning of each is given by specifying the result of its application to various kinds of objects. If PFOs are applied to any other kind of object, not mentioned in their meaning, the result of the application will be ⊥. This is read as "bottom" and denotes the undefined object or error. So, for example, an attempt to add the integer 1 to the character a will yield ⊥ since a is not the correct type for the + primitive.

The set of objects is determined by the set of atoms chosen. For example, if we choose to consider the set of integers, the set of nonempty strings, and the atoms T and F denoting true and false, then T, 66, −88, 0, c, Hello, F, and GHj are all valid atoms.

Considering now the set of objects that we can write down, we know that

- Every atom is an object.
- All sequences of objects, denoted by $<x_1, x_2, \ldots x_m>$ $m \geq 0$ (where each x_i is an object other than ⊥ $1 \leq i \leq m$), are objects.
- ⊥ is an object.
- Thus, <<66.7> ALA <GAB FO W>> is an object.

USER-DEFINED FUNCTIONS

The set of primitives and PFOs determines the set of functions that can be defined. The user can define functions using the def statement in FP. For example,

```
def MyFun = AFun → BFun; CFun
```

defines a function in terms of an FP PFO—in this case, the conditional. Note that AFun, BFun, and CFun must all be functions (which can themselves be built by the use of PFOs).

Each PFO takes a number of functions as parameters. The number of parameters is determined by the particular PFO. The "conditional" PFO takes three parameters, whereas the "construction" PFO can accept any number of function parameters. Recursive function definitions are allowed, so in the above example any of the expressions AFun, BFun, or CFun can refer to MyFun.

Note that the syntax for function application and composition in basic FP can be rather clumsy; for example, add:<2,3> as opposed to 2+3 or al:<2, <3,4,5> > as opposed to 2::<3,4,5>. However, it is easy to incorporate infix notation into many variable-free functional expressions. For example (using infixes ::, +), f::g represents al∘[f, g] and f+g represents +∘[f, g]. But note that if f = [h, g], +∘f is clearer than (1∘f) + (2∘f) or (1+2)∘f.

PROGRAMMING IN FP

A user-defined function is defined by one and only one definition. The name given to the function must be unique and must not coincide with the names associated with the primitive functions and PFOs. Remember that no part of a definition is a result itself; instead, each part is a function that must be applied to an argument to obtain a result.

Here are four simple examples of recursive user-defined functions:

```
def last = null∘tl → 1; last∘tl
def len  = null → 0̄ ; +∘[1̄, len∘tl]
def cat  = null∘1 → 2 ; al∘[1∘1, cat∘[tl∘1,2] ]
def fact = eq0 → 1̄ ; *∘[id, fact∘sub1]
```

(continued)

The first returns the last element of a sequence, the second returns the length of a sequence, the third catenates two sequences, and the last defines the factorial function.

Observe that the examples of function definitions given above, although written in FP, are written in a recursive style that is familiar from conventional functional languages such as Hope, LISP, and KRC. For instance, the definition of last says that if the tail of the sequence is empty then select the first element of object; otherwise, look for the last element of the tail of the object using a recursive call to last. In the FP style, it is often possible to replace an explicitly recursive definition by an equivalent nonrecursive functional expression.

The function last could, in most systems, be expressed purely in terms of primitives; for example, def last = 1r. Similarly a more natural FP definition for factorial is def f = (/ *)∘iota or, alternatively, def f = (\ *)∘iota. This "inserts" a * between each element of the sequence <1,2,. . .,*n*>.

A function to catenate (append in Hope) two sequences is def cat = (/ al)∘ar. This nonrecursive definition successively appends an item from the end of the first sequence onto the beginning of the second. Note that / cat will then be a function that catenates any number of sequences.

The function len, for length, would be a primitive in most systems, but if not, the more natural FP definition could be

$$\text{def len} = \text{null} \rightarrow \bar{0} \; ; \; + \circ (\alpha \bar{1})$$

This definition says that len:x is 0 if x is empty; otherwise, change each element of x into 1, and then add up the 1s. The items are literally counted!

Observe that the more natural FP solutions are nonrecursive (effectively the recursion has been pushed into the PFOs used). Although these nonrecursive definitions may look strange initially, they express an equally obvious solution. By becoming familiar with the high-level PFOs and their concise syntax, you can give concise, expressive, and flexible definitions that are often nonrecursive, using just a few symbols. (It has been suggested that programmer productivity is inversely proportional to the number of characters required in a program.)

Here, then, are some more complex examples that make use of the PFOs:

Vector Product: We can define the function VectorProduct to be def VP = (/ +)∘(α*)∘trans. Application of VP to a pair of equal-length vectors first creates the sequence of matched pairs of components (result of trans), then multiplies each pair, and finally sums these results. For nonequal-length vectors, the result of trans is ⊥ and so therefore is the result of VP. We can explain each step in evaluating VectorProduct applied to the pair of vectors < <1,2,3> , <6,5,4> > as shown in table 1.

Matrix Multiply: We can define the function MatrixMultiply to yield the product of any pair <y,z> of conformable matrices, where each matrix is represented as the sequence of its rows:

$y = < y_1, \ldots, y_m >$
 where $y_i = < y_{i1}, \ldots, y_{in} >$ for $i = 1, \ldots, m$
$z = < z_1, \ldots, z_n >$
 where $z_i = < z_{i1}, \ldots, z_{ip} >$ for $i = 1, \ldots, n$

The function is then defined as

def MM = (ααVP)∘(αdistl)∘distr∘ [1, trans∘2]

Binary Tree Insert: Suppose that a binary tree is represented by a sequence of three elements, where the first element is the left binary tree, the second is the data at the node (which we will assume is a number), and the third is the right binary tree. A function InsertInSortedBinaryTree (IISBT), which inserts a number into a tree in such a way that all elements in the left subtree are less than the smallest number in the whole of the right subtree, might look like this:

```
def IISBT = null∘1 → [ [ ], 2, [ ] ];
  le∘[2∘1, 2] → [ 1∘1, 2∘1, IISBT∘[3∘1, 2] ];
  [ IISBT∘[1∘1, 2], 2∘1, 3∘1 ];
```

Part Product: A function ParProds, when given a sequence of integers $< x_1, \ldots, x_m >$, produces a sequence of integers $< y_1, \ldots, y_m >$ such that, for $1 \leq i \leq m$,

$y_i = x_1 * \ldots * x_i$
Thus ParProds∘iota : 5 = <1,2,6,24,120>

i.e., the sequence of factorials of the numbers 1 through 5. We may start from the observation that

(continued)

Table 1: A *step-by-step explanation of the operation of* VP.

VP : < < 1,2,3> , <6,5,4> >	
By def of VP	=> (/+)∘(α*)∘trans:<<1,2,3>,<6,5,4>>
Effect of Composition	=> /+ :(α*:(trans:<<1,2,3>,<6,5,4>>)
Applying Transpose	=> /+ (α*:<<1,6>,<2,5>,<3,4>>)
Effect of ApplyToAll	=> /+ :<*:<1,6>,*:<2,5>,*:<3,4>>
Applying *	=> /+ :<6,10,12>
Effect of Insert	=> +:<6, +:<10,12>>
Applying +	=> +:<6,22>
Applying + Again	=> 28

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From a set of axioms that are not self-contradictory, an algebra may be defined.

```
ParProds : <x1,...,xm>
= PARar : < ParProds:<x1,...xm>, y>
where PARar = ar∘[1, *∘[1r∘1, 2]]
```

Unfortunately, we cannot simply right-insert the PARar function because it requires that the sequence to which it is applied has a sequence for its first element. We first have to make this element into a sequence. The function ParProds therefore becomes

```
def ParProds = null → 0̄;
  (\ PARar)∘al∘[ [1], tl]
def PARar = ar∘[1, *∘[ 1r∘1, 2]]
```

We may now use this nonrecursive function in the definition of other useful functions. For example, it is a relatively simple matter to extend these concepts for the evaluation of polynomials.

The FP Algebra of Programs

Just as a set of functions mapping a domain of objects into itself may define an algebra on that domain, so too may a set of functionals define an algebra on a domain of functions. The reader will probably be quite familiar with the concept of the field of real numbers (objects) under the composition rules of addition and multiplication (functions) that possess the necessary properties such as associativity; he or she is surely familiar with the well-known algebra that follows. In the same way, a set of axioms that are not self-contradictory may be defined on a set of functions under composition rules given by a set of functionals. From these axioms, it may be possible to establish, as theorems, further properties about the sets of functions and functionals; i.e., an algebra may be defined. Through the algebra, relationships between functions may be established as identities, independent of the domain of objects to which they are applied. The two sides of such an identity yield an equation at the object level for every argument to which they are each applied. Thus the functional algebra provides a more general, higher level of reasoning in which quite powerful arguments can be expressed and results deduced. Note that any set of axioms could be chosen provided they are consistent, but in order that the resulting algebra be useful, the axioms should not contradict known properties of conventional functional languages when the functions of each side of an identity are applied to objects. Thus, for example, we would not choose for an axiom the statement

```
f∘[g,h] = [f∘g, f∘h]
```

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Backus's set of axioms for FP is consistent but has not been shown to be complete.

for all functions f, g, h, since for object x, it is not true in general that

$$f{:}\langle g{:}x,\ h{:}x\rangle = \langle f{:}(g{:}x),\ f{:}(h{:}x)\rangle$$

However, we can and do choose

$$[g,h]\circ f = [g\circ f,\ h\circ f]$$

Backus has presented consistent axioms of the FP functional algebra (reference 3), although the set has not been shown to be exhaustive. When applied to an arbitrary object, each is duly seen to yield an equality that is known to hold. As a simple example of the use of the FP algebra in formal reasoning, we first prove the equivalence between the recursive and nonrecursive definitions of factorial considered above.

We know that, by definition,

$$iota = eq0 \rightarrow null;\ ar\circ[iota\circ sub1,id]$$

and FP laws state that for all functions f, g, h,

$$(\backslash f)\circ ar\circ[g,h] = f\circ[(\backslash f)\circ g,h]$$

(this is easily checked from the definition of \ ), and for Boolean-valued function p,

$$f\circ(p \rightarrow g;\ h) = p \rightarrow f\circ g;\ f\circ h$$

(easily checked from the definition of →). Thus,

$$\begin{aligned}(\backslash *)\circ iota &= eq0 \rightarrow (\backslash *)\circ null;\ (\backslash *)\circ ar\circ[iota\circ sub1,id]\\ &= eq0 \rightarrow \bar{1}\ ;\ *\circ[(\backslash *)\circ iota\circ sub1,id]\end{aligned}$$

and writing ! for $(\backslash *)\circ iota$ gives

$$! = eq0 \rightarrow \bar{1}\ ;\ *\circ[!\circ sub1,id]$$

The power of the algebra has been further developed and exploited by Williams (reference 4) and Backus (reference 5), who introduced the linear class of functional forms. A functional form is a functional expression that contains function variables, and a linear form possesses certain properties relating to function expansion, discussed below. A function f is defined to be (functionally) linear if it has the "else part" given by a linear form in f, i.e., f = p → q; Hf for some fixed functions p and q and linear form H. Linear functions such as f satisfy the Linear Expansion Theorem (LET), which states, loosely, that for object x, if f:x is defined, f:x = $(H^i q)$:x for some integer i, given by another form H_1 (the "predicate transformer") known in terms of H. Specifically, i is the least integer such that $(H_1{}^i p)$:x = T. This solution is clearly iterative at the function level of description—if a function

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FP SYNTAX

Examples of primitives that might be present in an FP system include the following:

Add, Subtract, Multiply, Equals, etc. (+, −, *, eq, etc.)
When x is of form <y,z> and y,z are numbers.
then +:x yields the sum of y and z
otherwise +:x = ⊥
(The others are defined similarly.)

Greater Than, Less Than, Less Than or Equal, etc. (gt, lt, le, etc.)
When x = <y,z> and y,z are numbers
then (if y>z then gt:x = T else gt:x = F)
(The others are defined similarly.)

And, Or, Not (and, or, not)
When x = < T, T> then and:x = T
When x = < F, T> or x = < T, F> or x = < F, F>
then and:x = F
(The others are defined similarly.)

Null (null)
When x = < > then null:x = T
When x = ⊥ then null:x = ⊥
otherwise null:x = F

Append Left (al)
When x = <y,< > > then al:x = <y>
When x = $<y, <z_1, \ldots, z_m>>$ then al:x = $<y, z_1, \ldots, z_m>$

Append Right (ar)
When x = << >,y> then al:x = <y>
When x = $<<z_1, \ldots, z_m>, y>$ then ar:x = $<z_1, \ldots, z_m, y>$

Selectors (1, 2, 3, . . .)
When x = $<z_1, \ldots, z_m>$ then if m ≥ i then i:x = z_i else ⊥

Right Selectors (1r, 2r, 3r, . . .)
As above, selects first, second, etc., from the right of the sequence.

Identity (id:x)
x

Transpose (trans)
When x = << >, . . . ,< >> then trans:x = < >
When x = $<x_1, \ldots, x_m>$ where $x_i = <x_{i1}, \ldots, x_{ik}>$
for 1 ≤ i ≤ m then trans:x = $<z_1, \ldots, z_k>$
where $z_j = <x_{1j}, \ldots, x_{mj}>$ for 1 ≤ j ≤ k
otherwise trans:x = ⊥

Distribute Left (distl)
When x = <y,< >> then distl:x = < > When x = $<y, <z_1, \ldots, z_m>>$
then distl:x = $< <y, z_1>, \ldots, <y, z_m>>$

Distribute Right (distr)
When x = << >,y> then distr:x = < >
When x = $< <z_1, \ldots, z_m>, y>$
then $< <z_1, y>, \ldots, <z_m, y> >$

Iota (iota)
if x = 0 iota:x = < > if x is a positive integer iota:x = <1,2, . . . ,x>
otherwise iota:x = ⊥

Others
Some other possible primitives are head (hd), tail (tl), right tail (trl), rotate left (rotl), rotate right (rotr), subract one (sub1), is equal to zero (eq0), and so on. Note that all these are just as easily written in FP using top primitives and the PFOs below. For example,

def eq0 = eq∘[id, $\bar{0}$]
def sub1 = −∘[id, $\bar{1}$]

Listed below are some examples of the type of PFOs that could be chosen for an FP system.

Composition
(f∘g):x = f:(g: x)

Construction
$[f_1, f_2, \ldots, f_m]$: x = $< f_1{:}x, f_2{:}x, \ldots, f_m{:}x >$

Condition
(p → f; g) : x = if (p:x) is T then f:x
else if (p:x) is F then g:x
else ⊥

Insert Left
/ f : x = if x = <y> then y
else if x = $<y_1, \ldots, y_m>$ and m ≥ 2
then f:$<y_1,$ / f:$<y_2, \ldots, y_m> >$
otherwise ⊥

Insert Right
\ f : x = if x = <y> then y
else if x = $<y_1, \ldots, y_m>$ and m ≥ 2
then f:< \ f:$<y_1, \ldots, y_{m-1}>, y_m>$
otherwise ⊥

Apply To All
αf : x = if x = < > then < >
if x = $<y_1, \ldots, y_m>$ then $<f{:}y_1, \ldots, f{:}y_m>$

Constant
$\bar{f}$: x = if x = ⊥ then ⊥
otherwise f
(Here f is an object parameter.)

To date, FP has been available only to researchers. Interpretive FP systems for relatively large computers have been implemented at such institutions as INRIA; the University of Paris; the University of California at Berkeley; and Westfield College and Imperial College, London. However, we at Imperial College hope to make an FP compiler for VAX and for conventional microcomputers such as the IBM PC available to the general public by the end of this year.

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Linear functions are typically translatable into iterative form.

could be "accumulated" by successively passing round a loop, its result after i cycles could simply be applied to the object x. Translation into a loop at the object level appears possible. The importance of expansion theorems in general is that they give nonrecursive solutions to the recursion equations defining certain functions. Further use of the FP algebra may also derive nonrecursive solutions as pure FP expressions from linear expansions (reference 4).

We have demonstrated that the linear functions constitute a well-behaved class. We will conclude the discussion of linearity by identifying some linear forms and indicating how they may be detected automatically. It can be shown that the primitive forms of composition, condition, and construction are linear and that the linear class is closed under functional composition. The closed property means that if a linear form is applied to a function argument, which is itself the result of applying another linear form to a function variable, the resulting, composite form is linear in the function variable. Thus the compiler can detect in many cases whether a defined function is linear and, if so, determine its predicate transformer, referred to above. For example, any form that is built up from the PFOs composition, construction, and condition and has only one occurrence of its function variable argument must be linear. More important, linear functions are typically translatable into iterative form, and the subject of current research at Imperial College is to automatically generate an iterative implementation (a loop) for a linear function, in particular any defined by a multiple composition of primitive linear forms.

Clearly then, the class of linear forms is an important one, and recent results (reference 6), again relying on the functional algebra, facilitate automatic transformation of a significant class of nonlinear functions into linear form, from which an iterative implementation follows (it is hoped). Mutually recursive definitions also may be similarly transformed under appropriate conditions, further extending the class of optimizable functions. Probably the prime example of these results is the transformation of the Fibonacci function into f = 1∘g where

g = le1 → [$\bar{1}$, $\bar{1}$]; [+,1]∘g∘sub1

By application of the linear expansion theorem for the linear form H given by Hg = [+,1]∘g∘sub1, with H_1a = a∘sub1 for function a,

g:x = $[+,1]^{x-1}$:<1, 1> = $[+,1]^{x-2}$:<2,1>
= $[+,1]^{x-3}$:<3,2> = . . .

(continued)

This reflects the usual way of implementing the Fibonacci iteration using two accumulators. [*Editor's note: Compare this with the Hope transformation of the same function in John Darlington's article on page* 201.] Further optimization is often possible for a set of mutually recursively defined functions (see reference 6). When such functions are combined with the linearization techniques used in the previous example, some powerful optimization becomes possible. Dijkstra's FUSC function satisfies the appropriate conditions and can be converted into iterative form. Denoting "divide by two" by d, s = sub1 and p = add1, FUSC is defined by

$$\text{fusc} = \text{le1} \rightarrow \text{id};\ \text{even} \rightarrow \text{fusc}\circ d;\ +\circ[\text{fusc}\circ d\circ p, \text{fusc}\circ d\circ s]$$

The theorem gives fusc = 1∘g where

$$\begin{aligned} g = {} & \text{le1} \rightarrow [\text{id}, s]; \\ & \text{le2} \rightarrow (\text{even} \rightarrow [L_0 g, s]; [M_0 g, s]); \\ & \text{even} \rightarrow [L_0 g, M_1 g]; [M_0 g, L_1 g] \end{aligned}$$

where $L_0 g = 1\circ g\circ d$, $L_1 g = 2\circ g\circ d\circ p$,
$M_0 g = +\circ g\circ d\circ p$, $M_1 g = +\circ g\circ d$

Thus the last branch of the definition for g (>2) becomes

$$\text{even} \rightarrow [1,+]\circ g\circ d;\ [+,2]\circ g\circ d\circ p$$

This reflects precisely the iteration of Dijkstra, and since the function is readily recognizable as linear in this form, the corresponding loop in an imperative programming language could be generated by the compiler. ■

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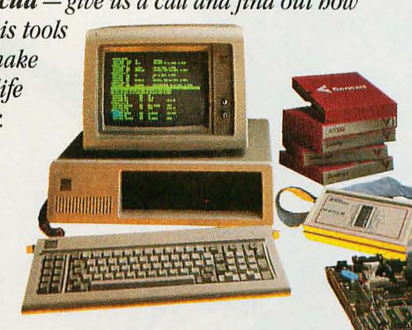
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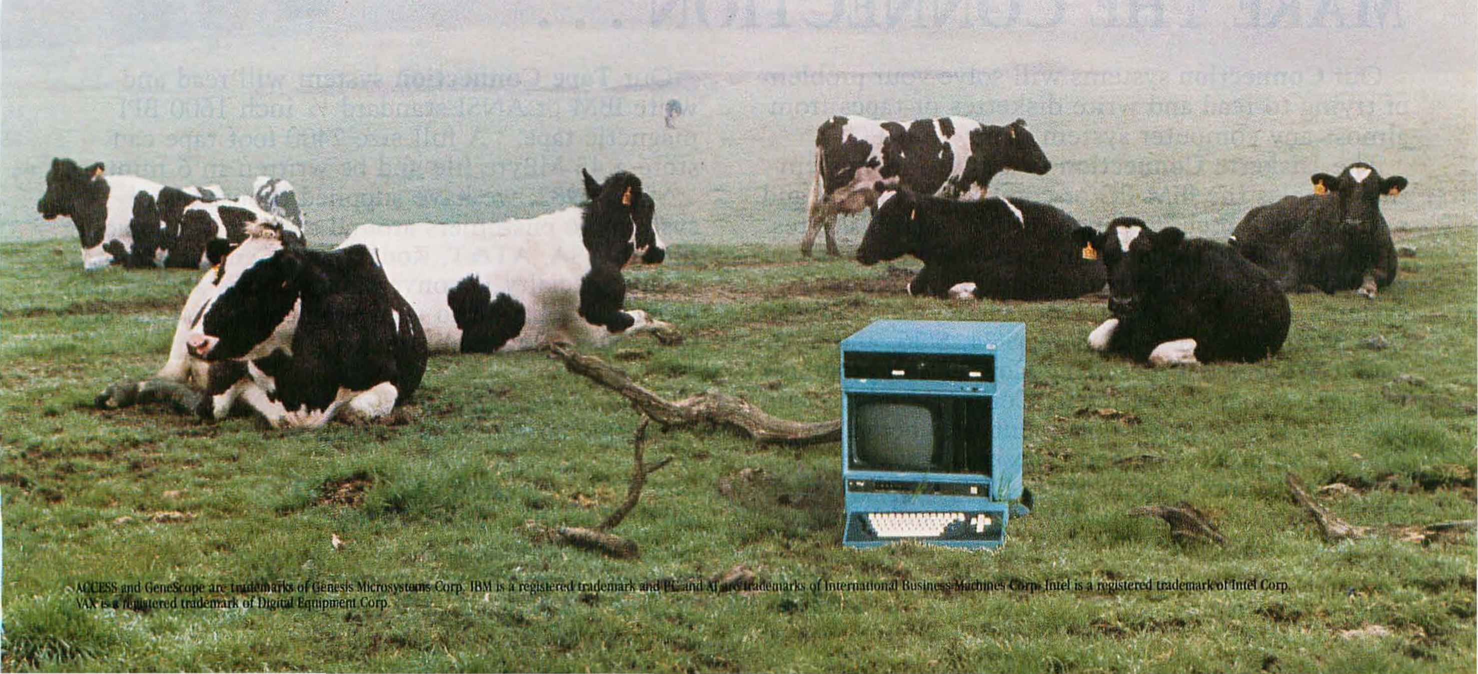


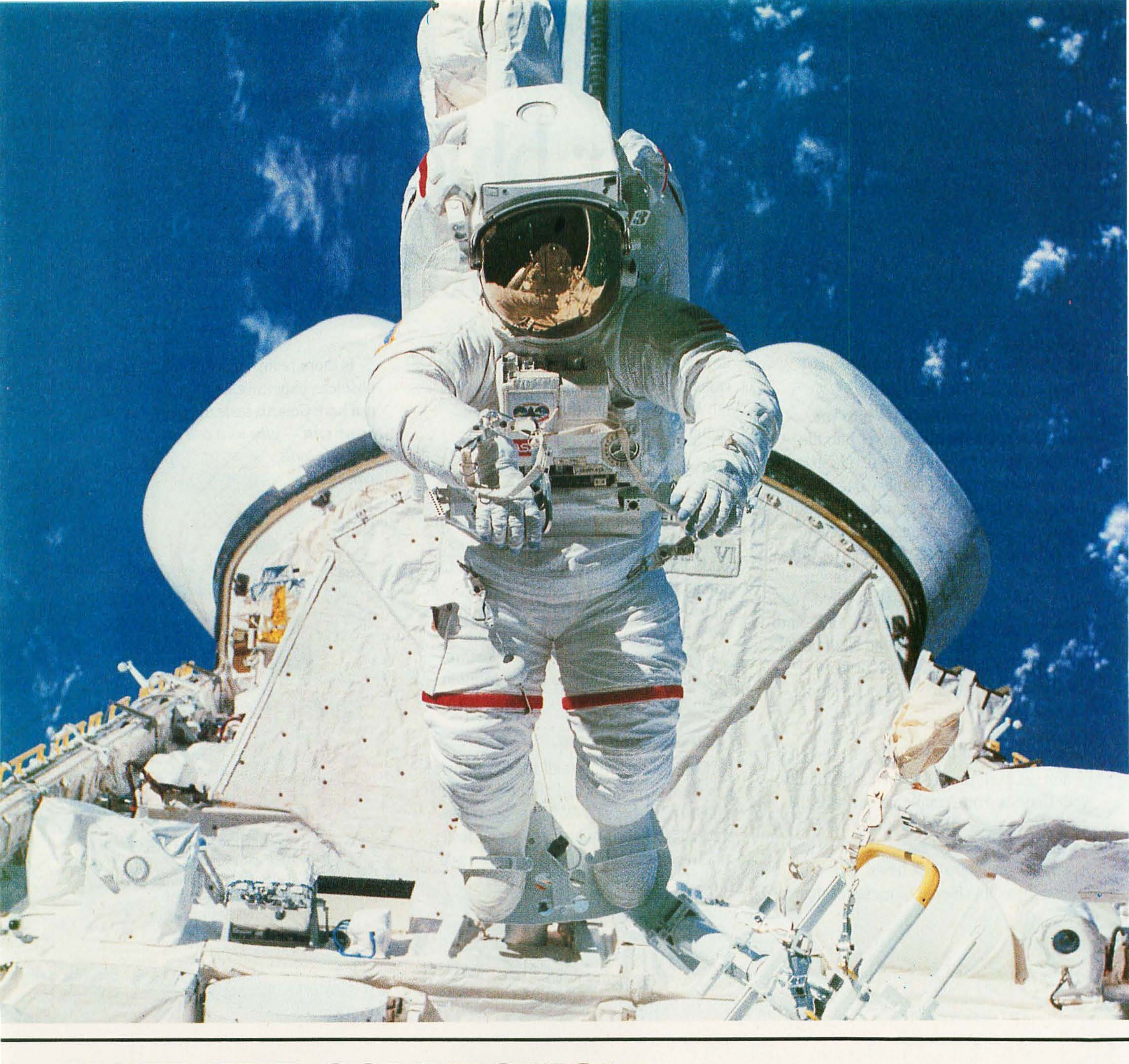
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A HOPE TUTORIAL

BY ROGER BAILEY

Using one of the new generation of functional languages

Editor's note: In this article we have boldfaced the output of the Hope interpreter to distinguish it from the input. The Hope interpreter is available for downloading from BYTEnet Listings *at* (617) 861-9774.

This version runs under PC-DOS 2.0; *you will need the files* HOPE.EXE *and* SYS.HOP. *Related articles are the* BYTE U.K. *column on page* 341 *of this issue and* BYTE U.K. *on page* 385 *of the May issue.*

IN A LANGUAGE LIKE PASCAL, a function is a piece of "canned" program for doing standard operations like finding square roots. When we want the square root of a positive number stored in a variable x, we write sqrt(x) at the point in the program where we want the value, such as writeln(1.0 + sqrt(x)). This is called an application of the function. The value represented by x is called the argument or actual parameter. In this context the function sqrt computes the square root of x, 1.0 is added to it, and the result is then printed.

We can also define our own functions specifying how the result is computed using ordinary Pascal statements. Here's a function that returns the greater of its two argument values:

```
function max(x,y:INTEGER):INTEGER;
begin
  if x>y
  then max := x
  else max := y
end;
```

The identifiers x and y are called formal parameters. They're used inside the definition to name the two values that will be supplied as arguments when the function is applied. Here's how we might use max to filter out negative values: writeln(max(z,0));.

A more interesting case is when the actual parameter is a function application itself or involves one. We can use max to find the largest of three numbers by writing max(a,max(b,c)).

Combining functions like this is called composition. The expression is evaluated "inside out" because the outer application of max can't be evaluated until the value of its second argument is known. The inner application of max is therefore evaluated first using the values of b and c; the result is used as the actual parameter in the outer application.

Another way to combine functions is to define more powerful ones by using simpler ones as building blocks. If we often need to find the largest of three numbers, we might define

```
function MaxOf3(x,y,z:INTEGER):INTEGER;
begin
  MaxOf3 := max(x,max(y,z))
end;
```

and apply it by writing MaxOf3(a,b,c).

PROGRAMMING WITH FUNCTIONS

Pascal is called an imperative language because programs written in it are recipes for doing something. If our programs consist only of functions, we can concentrate on the results and ignore how they're computed. Forget that

(continued)

Roger Bailey can be reached at the Department of Computing, Imperial College, 180 Queen's Gate, London SW7 2BZ, England.

sqrt is a piece of code and think of sqrt(x) as a way of writing a value in your program, and you'll get the idea. You can think of MaxOf3 in the same way if you ignore the way it works inside. By defining a toolkit of useful functions and combining them, we can build powerful programs that are short and easy to understand.

In Pascal, functions can return only simple data objects such as numbers or characters, but real programs use big data structures and can't easily be written using these functions. In Hope, functions can return any type of value, including data structures equivalent to Pascal's arrays, records, and much more. Programming in Hope has the flavor of simply writing down the answer by writing an expression that defines it. This expression will contain one or more function applications to define smaller parts of the answer. These won't usually be built in like sqrt, so we'll have to define them ourselves, but we'll still think of them as definitions of data objects, not as algorithms for computing them.

A Simple Hope Example—Conditionals

Let's see how we can define max in Hope. Like Pascal, Hope is a strongly typed language; we must tell the compiler about the types of objects in our programs so it can check that they're used consistently. The function definition comes in two parts—the declaration followed by one or more recursion equations. First we declare the argument and result types:

```
dec max : num # num -> num;
```

dec is a reserved word (must be in lowercase) signaling the start of the declaration of the function max, which takes two numbers as arguments and returns a single number as its result. Read the symbol : as "takes a." Names consist of uppercase and lowercase letters (which are distinct) and digits and must start with a letter. The current fashion is to use lowercase. You can separate symbols with any number of blanks and new lines for clarity. A space or new line is needed only when adjacent symbols might be confused as one symbol without it.

The next part of the declaration gives the types of the arguments. Integers are of the predefined type num (in lowercase). Read # as "and a"; alternatively, you can use the reserved word X. Read -> as "yields." The semicolon marks the end of the declaration. max needs only one recursion equation to define it.

```
--- max(x,y) <= if x>y then x else y;
```

Read the symbol --- as "the value of." The expression max(x,y) is called the left-hand side of the equation. It defines x and y as formal parameters or local names for the values that will be supplied when the function is applied. Parameter names are local to the equation, so x and y won't be confused with any other x or y in the program. The symbol <= is read as "is defined as."

The rest of the equation (called the right-hand side) defines the result. It's a conditional expression. The symbols if, then, and else are reserved words. If the value of the subexpression x > y is true, the value of the whole conditional expression is the value of x; otherwise, it's the value of y. The two alternative values can be defined by any Hope expression.

While Pascal's conditional statement causes one of two actions to be performed, Hope's conditional expression specifies one of two values. Hope doesn't specify the order in which the two expressions are evaluated. On a computer that uses parallel processing, such as the Imperial College ALICE machine, it's even possible to evaluate all three expressions in parallel and throw away one of the results when the value of the condition is known.

Using Functions We've Defined

A Hope program consists of a single expression containing one or more function applications. When the expression is evaluated, the result and its type are printed on the screen. Here's a simple program that uses max:

```
max(10,20) + max(1,max(2,3));
23 : num
```

The rules for evaluating the expression are the same as those in Pascal. Function arguments are evaluated first, the functions are applied, and finally other operations are performed in the usual order of priority.

We can also use existing functions to define new ones. Here's the Hope version of MaxOf3:

```
dec MaxOf3 : num # num # num -> num;
--- MaxOf3(x,y,z) <= max(x,max(y,z));
```

A More Interesting Example

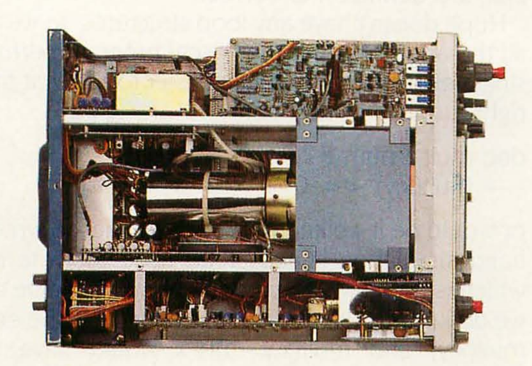
Just as Pascal's conditional statement is replaced by Hope's conditional value, so the repetitive statement is replaced by the repetitive value. Here's a Pascal function that multiplies two numbers using repeated addition:

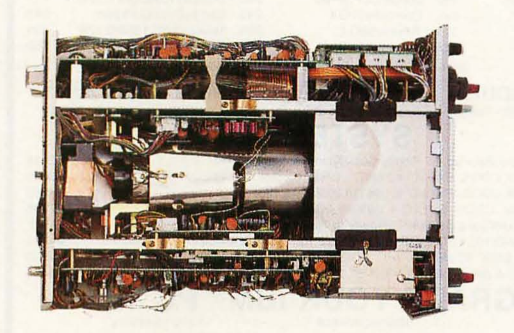
```
function mult(x,y:INTEGER):INTEGER;
  var prod:INTEGER;
  begin
    prod := 0;
    while y>0 do
      begin
        prod := prod + x;
        y := y-1
      end;
    mult := prod
  end;
```

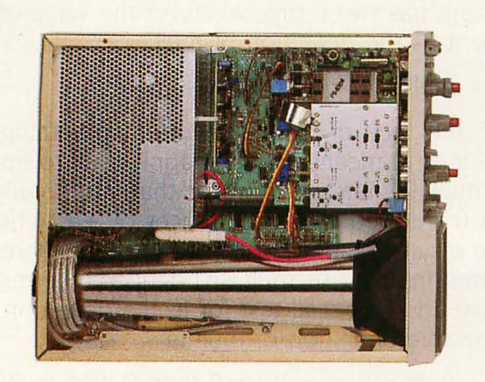
It's hard to be sure this function does enough additions (it took me three tries to get it right), and this seems to be a general problem with loops in programs. A common way of checking imperative programs is to simulate their execution. If we do this for input values of 2 and 3, we'll

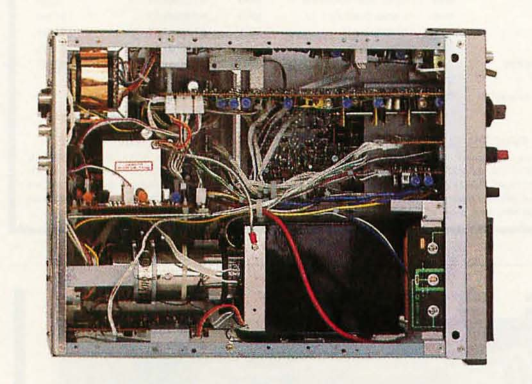
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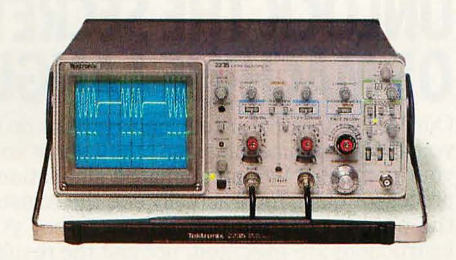
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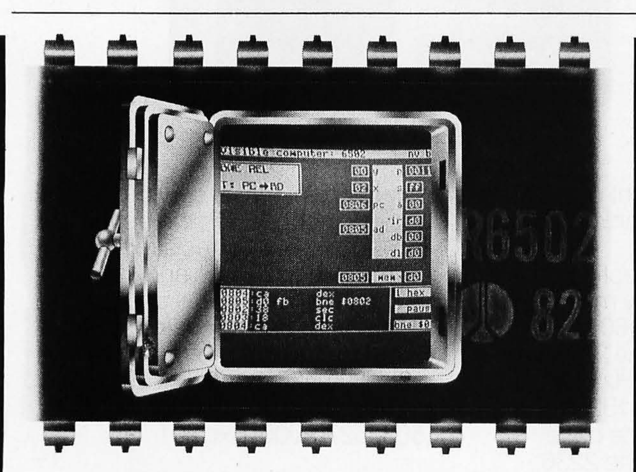
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find that prod starts with the value 0 and gets values of 2, 4, and 6 on successive loop iterations, which suggests that the definition is correct.

Hope doesn't have any loop structures, so we must write all the additions that the Pascal program performed in a single expression. It's much easier to see that this has the right number of additions:

```
dec mult : num # num -> num ;
--- mult(x,y) <= 0 + x + x + ...
```

or would be if we knew how many times to write +x. The hand simulation suggests we need to write it y times, which is tricky when we don't know the value of y. What we do know is that for a given value of y, the expressions mult(x,y) and mult(x,y−1)+x would have the same number of +x terms if written out in full. The second one always has two terms, whatever the value of y, so we'll use it as the definition of mult:

```
--- mult(x,y) <= mult(x,y-1)+x;
```

On the face of it we've written something ridiculous, because it means we must apply mult to find the value of mult. Remember, however, that this is really shorthand for 0 followed by y occurrences of +x. When y is zero, the result of mult is also zero because there are no +x terms. In this case, mult isn't defined in terms of itself, so if we add a special test for it, the definition terminates. A usable definition of mult is

```
--- mult(x,y) <= if y=0 then 0 else mult(x,y-1)+x;
```

Functions that are defined using themselves like this are called recursive. Every Pascal program using a loop can be expressed as a recursive function in Hope. All recursive definitions need one case (called the base case) where the function isn't defined in terms of itself, just as Pascal loops need a terminating condition.

ANOTHER WAY OF USING FUNCTIONS

Hope enables us to use a function with two arguments as an infix operator. We must assign it a priority and use it as an infix operator everywhere, including the equations that define it. The definition of mult used as an infix operator looks like this:

```
infix mult : 8;
dec mult : num # num -> num;
--- x mult y <= if y=0 then 0 else x mult(y-1)+x;
```

A bigger number in the infix declaration means a higher priority. Since a priority of 8 is higher than that of the subtraction operator, mult's second argument, y−1, in the recursion equation must be in parentheses. Most of Hope's standard functions are supplied as infix operators.

OTHER KINDS OF DATA

Hope provides two other primitive data types. A truval is equivalent to Pascal's Boolean data type and has values

(continued)

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true or false. We've already seen an example of an expression that defines a truval: x>y. > is a standard function whose type is num # num -> truval. We can use truvals in conditional expressions and combine them with the standard functions and, or, and not.

Single characters are of type char, with values 'a', 'b', and so on. Characters are most useful as components of data structures such as character strings.

Data Structures

Practical programs need data structures, and Hope has two standard kinds already built in. The simplest kind, called a tuple, corresponds to a Pascal record. We can bind a fixed number of objects of any type together into a tuple. For example: (2,3) and ('a',true) are tuples of the type num # num and char # truval, respectively.

We use tuples when we want a function to define more than one value. Here's one that takes the time of day defined in terms of seconds since midnight and converts it to hours, minutes, and seconds:

```
dec time24 : num -> num # num # num;
--- time24(s) <= (s div 3600,
                  s mod 3600 div 60,
                  s mod 3600 mod 60);
```

div is the built-in integer division function, and mod gives the remainder after integer division. If we type an application of time24 at the terminal, the resulting tuple and its type will be printed on the screen in the usual way.

```
time24(45756);
(12,42,36) : (num # num # num)
```

The second standard data type, called a list, corresponds roughly to a one-dimensional array in Pascal. It can contain any number of objects (including none at all), but they must all be the same type. For example, [1,2,3] is an expression of type list(num).

There are two standard functions for defining lists. The infix operator :: (pronounced "cons") defines a list in terms of a single object and a list containing the same type of object:

```
10 :: [20,30,40] defines the list [10,20,30,40]
```

Don't think of :: as adding 10 to the front of [20,30,40]. It really defines a new list, [10,20,30,40], in terms of two other objects without changing their meaning, rather in the same way that 1 + 3 defines a new value of 4 without changing the meaning of 1 or 3.

The other standard list function is nil, which defines a list with no elements in it. We can represent every list by an expression consisting of applications of :: and nil. When we write an expression like

```
['c','a','t']
```

Hope considers it to be just a shorthand way of writing

(continued)

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```
'c' :: ('a' :: ('t' :: nil))
```

Another shorthand way of writing lists of characters is to enclose the character string in double quotes: "cat". When the result of a Hope program is a list of numbers, it's printed out in the concise bracketed notation; if it's a list of characters, it's printed in quotes.

Every data type in Hope is defined by a set of primitive functions like :: and nil. They're called constructor functions and aren't defined by recursion equations. When we defined a tuple, we were actually using a standard constructor called , (pronounced "comma"). Later on we'll see how constructors are defined for other types of data.

FUNCTIONS THAT DEFINE LISTS

If we wanted to write a Pascal program to print the first n natural numbers in descending order, we'd probably write a loop that printed one value out on each iteration. For example,

```
for i: = n downto 1 do write(i);
```

In Hope we write one expression that defines all the values at once, rather like we did for mult:

```
dec nats : num -> list(num);
--- nats(n) <= if n=0 then nil else n::nats(n-1);
```

nil is useful for writing the base case of a recursive function that defines a list. If we try the function at the terminal by typing

```
nats(10);
[10,9,8,7,6,5,4,3,2,1] : list(num)
```

the numbers are in descending order because that's the way we arranged them in the list, not because they were defined in that order. The values in the expression defining the list are treated as though they were all generated at the same time. On the ALICE machine they actually are generated at the same time. To get the results of a Hope program in the right order, we must put them in the right place in the final data structure.

If we want the list of the natural numbers n through 1 in ascending order, we need to use another built-in operation, <> (pronounced "append"), that concatenates two lists.

```
--- nats(n) <= if n=0 then nil else nats(n-1) <> [n];
```

We put n in brackets to make it into a (single-item) list because <> expects both its arguments to be lists. We could also have written (n::nil) instead of [n].

DATA STRUCTURES AS PARAMETERS

Suppose we have a list of integers and we want to write a function to add up all its elements. The declaration will look like this:

```
dec sumlist : list(num) -> num;
```

We need to refer to the individual elements of the actual parameter in the equations defining sumlist. We do this using an equation whose left-hand side looks like this:

```
--- sumlist(x :: y) . . .
```

This is an expression involving list constructors and corresponds to an actual parameter that is a list. x and y are formal parameters, but they name individual parts of the actual parameter value. In an application of sumlist like

```
sumlist([1,2,3])
```

the actual parameter will be "dismantled" so that x names the value 1 and y names the value [2, 3]. The complete equation will be

```
--- sumlist(x :: y) <= x + sumlist(y);
```

Notice there's no base case test. As we might expect, it's the empty list, but we can't test for it directly in the equation because there's no formal parameter that refers to the whole list. In fact, if we write the application

```
sumlist(nil)
```

we'll get an error message because we can't dismantle nil to find the values of x and y. We must cover this case separately using a second recursion equation:

```
--- sumlist(nil) <= 0;
```

The two equations can be given in either order. When sumlist is applied, the actual parameter is examined to see which constructor function was used to define it. If the actual parameter is a nonempty list, the first equation is used, because nonempty lists are defined using the :: constructor. The first number in the list gets named x and the remaining list y. If the actual parameter is the empty list, the second equation is used because empty lists are defined using the constructor nil.

PATTERN MATCHING

An expression composed of constructors appearing on the left-hand side of a recursion equation is called a pattern. Selecting the right recursion equation and dismantling the actual parameter to name its parts is called pattern matching. When you write a function, you must give a recursion equation for each possible constructor defining the argument type.

Sometimes we don't need to dismantle the actual parameter, and we can use a formal parameter in the pattern that matches the whole object, irrespective of what constructors were used to define it. As an example, let's see how we could define our own version of the append function to concatenate two lists. Let's call it cat.

```
infix cat : 4;
dec cat : list(num) # list(num) -> list(num);
--- (h :: t) cat r <= h :: (t cat r);
--- nil cat r <= r;
```

The first list parameter is matched by the pattern (h::t)

(continued)

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so that its first item (the "head") and the remaining list (the "tail") can be referred to separately on the right-hand side. The second recursion equation covers the case when the first list is empty. The second list parameter is matched by the pattern r whether it's empty or not.

In addition to writing enough recursion equations to satisfy all the parameter constructors, we must also be careful not to write sets of equations in which more than one pattern might match the actual parameters, because that would be ambiguous.

We can write patterns to match arguments that are tuples in the same way. When we wrote mult(x,y) you probably thought the parentheses and the comma had something to do with the function application. In fact, we were constructing a tuple, and the parentheses were needed only because the tuple constructor (,) has a low priority. Hope treats all functions as having only one argument. This can be a tuple when you want the effect of several arguments. Without the parentheses

```
mult x, y
```

would be interpreted as

```
( mult ( x ), y )
```

A recursion equation with the left-hand side

```
--- mult ( x, y ) <= . . .
```

is just a pattern match on a tuple. The first item in the tuple gets named x and the second one y.

We can even use pattern matching on num parameters. These are defined by two constructors called succ and 0. succ defines a number in terms of the next lower one. 0 has no arguments and defines the value zero. Surely 0 is a value, not a function? Well, we're already used to thinking of function applications as another way of writing values, so it's quite consistent to think of 0 as a function application. Here's a version of mult that uses pattern matching to identify the base case:

```
infix mult : 8;
dec mult : num # num -> num;
--- x mult 0        <= 0;
--- x mult succ(y)  <= (x mult y)+x;
```

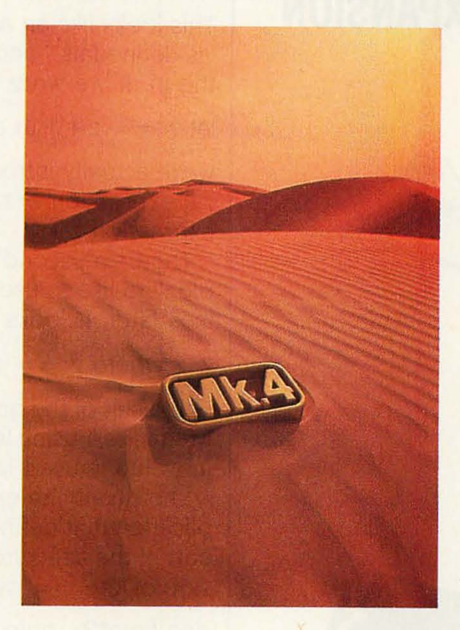
We can read succ(y) as "the successor of some number that we'll call y." Instead of naming the actual parameter y as we did in the original version of mult, we're naming its predecessor.

SIMPLIFYING EXPRESSIONS

In Pascal programs we can simplify complex expressions by removing common subexpressions and evaluating them separately. Instead of writeln((x+y)*(x+y));, we would probably write z := x+y; writeln(z*z);, which is clearer and more efficient. Hope programs consist only of expressions, and it's even more important to simplify them. We do this by using a qualified expression:

(continued)

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Inquiry 213

```
let z == x+y in z*z;
```

This looks like an assignment, but it isn't. == is read as "is defined as," and z is local to the expression following the in. If we write something like

```
let z == z+1 in z*z;
```

we're actually introducing a new variable, z, to use in the subexpression z*z. It hides the original one in the subexpression z+1.

There's a second form of qualified expression for people who like to use variables first and define their meanings later. It looks like this:

```
z*z where z == x+y;
```

The result of the qualified expression is the same whether we define it using let or where. x+y is evaluated first, and its value is used in the main expression.

The qualifying expression will often be a function application that defines a data structure. If we want to name part of the structure, we can use a pattern on the left-hand side of the == symbol.

```
dec time12 : num -> num # num;
--- time12(s) <= (if h>12 then h - 12 else h,m) where
                 (h,m,s) == time24(s);
```

We'll use this construction most often when we write recursive functions that define tuples. Suppose, for example, that we want to form a string of words from a sentence. For simplicity, a word is taken to be any sequence of characters, and words are separated in the sentence by any number of blanks. The sentence and a single word will be list (char) objects and the final sequence of words a list(list(char)).

It's fairly straightforward to obtain the first word. Here's a function that does it:

```
dec firsttry : list(char) -> list(char);
--- firsttry(nil)      <= nil;
--- firsttry(c :: s)   <= if c=' '
                          then nil
                          else c :: firsttry(s);
```

One of the nice features of Hope is that we can type in and print out any kind of value, so it's easy to check out the individual functions of our program separately. If we test firsttry we'll see

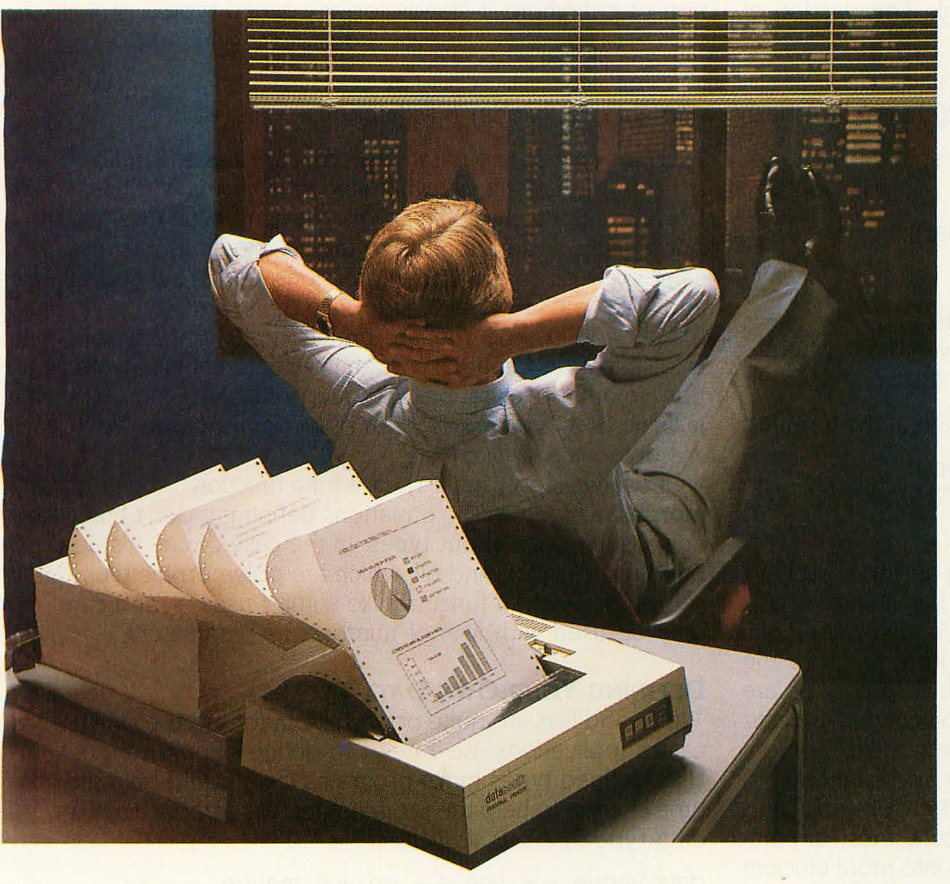
```
firsttry ( "You may hunt it with forks and Hope" ) ;
"You" : list ( char )
```

But there's a problem here, because we're going to need the rest of the sentence if we're to find the remaining words. We must arrange for the function to return the remaining list as well as the first word. This is where tuples come in:

```
dec firstword : list(char) -> list(char) # list(char);
--- firstword(nil)      <= (nil, nil);
```

(continued)

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```
--- firstword(c :: s)  <= if c = ' '
                            then (nil,s)
                            else ((c :: w, r) where
                                (w,r) == firstword(s));
```

The qualified expression is in parentheses so it only applies to the expression after else; otherwise we would evaluate firstword recursively as long as the sentence is nonempty, even if it starts with a blank. This version of the function produces

```
firstword("Hope springs eternal . . .");
("Hope","springs eternal . . .") : (list(char) # list(char))
```

We can use this to define a function to split the sentence into a list of its individual words:

```
dec wordlist : list(char) -> list(list(char));
--- wordlist(nil)      <= nil;
--- wordlist(c :: s)   <= if c=' '
                           then wordlist(s)
                           else (w :: wordlist(r) where
                             (w,r) == firstword (c :: s));
```

which we can test by typing an application at the terminal:

```
wordlist(" While there's life there's Hope ");
["While","there's","life","there's","Hope"] :
list(list(char))
```

So far we've concentrated on features of Hope that have something in common with traditional languages such as Pascal, but without many of their limitations, such as fixed-size data structures. We've also been introduced to the functional style of programming in which programs are no longer recipes for action but definitions of data objects.

Now we'll introduce features of Hope that lift it onto a much higher level of expressive power and enable us to write programs that not only are extremely powerful and concise but that can be checked for correctness at compile time and mechanically transformed into more efficient versions.

More Powerful Functions

The Hope compiler can spot many common kinds of errors by checking the types of all objects in expressions. This is harder than checking at run time, but it is more efficient and saves the embarrassment of discovering an error at run time in a rarely executed branch of the air traffic control system we just wrote.

However, strict type checking can be a nuisance if we want to perform some operation that doesn't depend on the type of the data. Try writing a Pascal procedure to reverse an array of either 10 integers or 10 characters, and you'll see what I mean.

Hope avoids this kind of restriction by allowing a function to operate on more than one type of object. We've already used the standard constructors :: and nil to define a list(num), a list(char), and a list(list(char)). The standard equality function = compares any two objects of the same type. Functions with this property are called polymorphic. Pascal's built-in functions abs and sqr and operators like > and = are polymorphic in a primitive kind of way.

We can define our own polymorphic functions in Hope. The function cat we defined earlier concatenates lists of numbers, but we can use it for lists containing any type of object. We do this by first declaring a kind of "universal type" called a type variable. We use this in the declaration of cat where it stands for any actual type.

```
typevar alpha;
infix cat : 8;
dec cat : list (alpha) # list(alpha) -> list(alpha);
```

This says cat has two parameters that are lists and defines a list, but it doesn't say what kind of object is in the list. However, alpha always stands for the same type throughout a given declaration, so all the lists must contain the same type of object. The expressions [1,2,3] cat [4,5,6] and "123" cat "456" are valid, while the expression [1, 2, 3] cat "456" is not. The interpretation of a type variable is local to a declaration so it can have different interpretations in other declarations without confusion. [*Editor's note: In the version of Hope available on BYTEnet, the type variables* alpha *and* beta *are predefined.*]

Of course, it only makes sense for a function to be polymorphic as long as the equations defining it don't make any assumptions about types. In the case of cat, it's defined using only :: and nil, which are polymorphic themselves. However, a function like sumlist uses + and can only be used with lists of numbers as parameters.

Defining Your Own Data Types

Tuples and lists are quite powerful, but for more sophisticated applications we'll need to define our own types. User-defined types make programs clearer and help the type checker to help the programmer. We introduce a new data type in a *data declaration*.

```
data vague == yes ++ no ++ maybe;
```

data is a reserved word and vague is the name of the new type. == is pronounced "is defined as" and ++ is pronounced "or." yes, no and maybe are the names for the constructor functions of the new type. We can now write function definitions that use these constructors in pattern matches:

```
dec evade : vague       -> vague ;
--- evade ( yes )       <= maybe ;
--- evade ( maybe )     <= no ;
```

The constructors can be parameterized with any type of object, including the type that's being defined. We can define types like lists, whose objects are of unlimited size using this kind of recursive definition. Here's a user-defined binary tree that can contain numbers as its leaves:

```
data tree == empty ++ tip(num) ++ node(tree # tree);
```

(continued)

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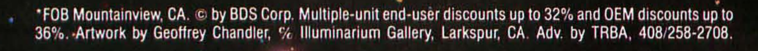
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There are three constructors: empty has no parameters and defines a tree with nothing in it, tip defines a tree in terms of a single number, and node defines a tree in terms of two other trees. Figure 1 shows a typical tree.

Here's an example of a function that manipulates trees. It returns the sum of all the numbers in the tree:

```
dec sumtree : tree -> num;
--- sumtree (empty)     <= 0;
--- sumtree (tip(n))    <= n;
--- sumtree (node(l,r)) <= sumtree(l) + sumtree(r);
```

(continued)

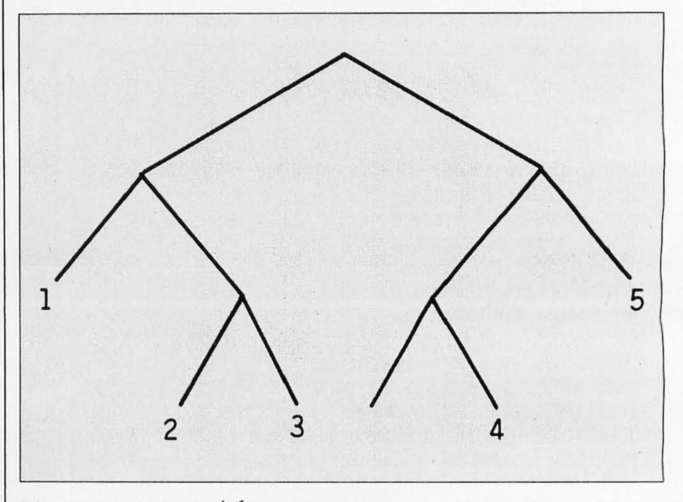


Figure 1: *A typical binary tree.*

Listing 1a: *The polymorphic function* flatten *can operate on trees of any type object.*

```
dec flatten : tree(alpha) -> list(alpha);
--- flatten(empty)      <= nil;
--- flatten(tip(x))     <= x :: nil;
--- flatten(node(x,y))  <= flatten(x) <> flatten(y);
```

Listing 1b: *These examples demonstrate the function* flatten *on various types of trees.*

```
flatten(node(tip(1),node(tip(2),tip(3))));
[ 1, 2, 3 ] : list
flatten(node(tip("one"),
             node(tip("two"),
                  tip("three"))));
["one","two","three"] : list(list(char))
flatten(node(tip(tip('a')),
             node(tip(empty),
                  tip(node(tip('c'),
                           empty)))));
[ tip('a'),empty,node(tip('c'), empty) ] : list(tree(char))
```

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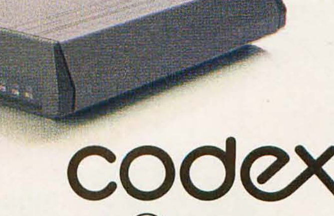
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Unfortunately, there's no shorthand for writing tree constants like there is for list constants, so we've got to write them out the long way using constructors. If we want to use sumtree to add up all the numbers in the example tree, we must type in the expression

```
sumtree(node(node(tip(1),
                  node(tip(2),
                       tip(3))),
              node(node(empty,
                        tip(4)),
                   tip(5))));
```

This isn't really a drawback because programs that manipulate complex data structures like trees will generally define them using other functions. However, it's very useful to be able to type any kind of constant data structure at the terminal when we're checking out an individual function like sumtree. If we want to test a Pascal program piecemeal, we'll usually have to write elaborate test harnesses or stubs to generate test data.

Making Data More Abstract

The identifier list isn't really a Hope data type. It's called a type constructor and must be parameterized with an actual type before it represents one. We did this every time we declared a list(num) or a list(char). The parameter can be a user-defined type, as with a list(tree), or even a type variable, as in list(alpha), which defines a polymorphic data type. Constructing new data types like this is a compile-time operation, not to be confused with constructing new data values, which is a run-time operation.

You can define your own polymorphic data types. Here's a version of the binary tree we defined earlier that can have any type of value in its leaves:

```
data tree(alpha) == empty ++
                    tip(alpha) ++
                    node(tree(alpha) # tree(alpha));
```

Once again, alpha is taken to be the same type throughout one instance of a tree. If it's a number, then all references to tree(alpha) are taken as references to tree(num).

We can define polymorphic functions that operate on trees of any type of object because our tree constructors are now polymorphic. Listing 1 shows a function to "flatten" a binary tree into a list of the same type of object.

Even More Concise Programs

The importance of polymorphic types and functions is that they let us write shorter, clearer programs. It's rather like the way Pascal subroutines let us use the same code to operate on different data values, but much more powerful. We can write one Hope function to reverse a list of numbers or characters, while we'd need to write two identical Pascal subroutines to reverse an array of integers and an array of characters.

We can use polymorphic functions whenever we're con-

(continued)

cerned only with the "shape" of a data structure and not with the objects in it. Sometimes, however, we'll also want to apply some function to the primitive data items in the structure. Here's a function that defines a list(num) whose elements are the squares of another list(num) using a function called square:

```
dec square : num -> num;
--- square(n) <= n*n;

dec squarelist : list(num) -> list(num);
--- squarelist(nil)        <= nil;
--- squarelist(n :: l)  <= square(n) :: squarelist(l);
```

Every time we write a function to process every element of a list, we'll write something almost identical to squarelist. Here's a function to define a list of factorials:

```
dec fact : num -> num;
--- fact(0)          <= 1;
--- fact(succ(n)) <= succ(n) * fact(n);

dec factlist : list(num) -> list(num);
--- factlist(nil)       <= nil;
--- factlist(n :: l)   <= fact(n) :: factlist(l);
```

factlist has exactly the same "shape" as squarelist; it just applies fact instead of square and then applies itself recursively. Values that differ between applications are usually supplied as actual parameters. Hope treats functions as data objects, so we can do this in a perfectly natural way. A function that can take another function as an actual parameter is called a higher-order function. When we declare it we must give the type of formal parameter standing for the function in the usual way. The declaration of fact tells us it's num -> num. Read this as "a function mapping numbers to numbers."

Now let's see how we can use this idea to write factlist and squarelist as a single higher-order function. The new function needs two parameters—the original list and the function that is applied inside it. Its declaration will be

```
dec alllist : list(num) # (num -> num) -> list(num);
```

The "shape" of alllist is the same as factlist and squarelist, but the function we apply to each element of the list will be the formal parameter.

```
--- alllist(nil, f)     <= nil;
--- alllist(n :: l, f) <= f(n) :: alllist(l,f);
```

We use alllist like this:

```
alllist( [2,4,6], square );
[ 4,16,36 ] : list ( num )

alllist( [ 2,4,6 ], fact );
[ 2,24,720 ] : list ( num )
```

Notice that there is no argument list after the functions square or fact in the application of alllist, so this construction will not be confused with functional composition. fact(3) represents a function application, but fact by itself represents the unevaluated function.

Higher-order functions can also be polymorphic. We can use this idea to write a more powerful version of alllist that will apply an arbitrary function to every element of a list of objects of arbitrary type. This version of the function is usually known as map:

```
typevar alpha, beta ;

dec map : list(alpha) # (alpha -> beta) -> list(beta);
--- map(nil, f)     <= nil;
--- map(n :: l, f) <= f(n) :: map(l,f);
```

The definition now uses two type variables, alpha and beta. Each one represents the same actual type throughout one instance of map, but the two types can be different. This means we can use any function that maps alphas to betas to generate a list of betas from any list of alphas.

The actual types aren't restricted to scalars, which makes map rather more powerful than we might realize at first sight. Suppose we've got a suitably polymorphic function that finds the length of a list:

```
typevar gamma;
dec len : list(gamma) -> num;
--- len(nil)      <= 0;
--- len(n :: l) <= 1 + len(l);

len( [2,4,6,8] ) + len("cat");
7 : num
```

We can use map to apply len to every element of a list of words defined by wordlist:

```
map(wordlist("The form remains, the function never
   dies"), len);
[ 3,4,8,3,8,5,4 ] : list ( num ) ;
```

In this example alpha is taken to be of type list(char) and beta to be a number, so the type of the function must be (list(char) -> num). len fits the bill if gamma is taken to be of type char.

COMMON PATTERNS OF RECURSION

map is powerful because it sums up a pattern of recursion that turns up frequently in Hope programs. We can see another common pattern in the function len used above. Here's another example of the same pattern:

```
dec sum : list(num) -> num;
--- sum(nil)      <= 0;
--- sum(n :: l) <= n + sum(l);
```

The underlying pattern consists of processing each element in the list and accumulating a single value that forms the result. In sum, each element contributes its value to the final result. In len, the contribution is always 1 irrespective of the type or value of the element, but the pattern is identical. Functions that display this pattern are of type (list(alpha) -> beta).

(continued)

In the function definition, the equation for a nonempty list parameter specifies an operation whose result is a beta. This is + in the case of len and sum. One argument of the operation will be a list element, and the other will be defined by a recursive call, so the type of the operation needs to be

```
( alpha # beta -> beta )
```

This operation differs between applications, so it must be a parameter. Finally, we need a parameter of type beta to specify the base case result. The final version of the function is usually known as reduce, and its definition looks like this:

```
dec reduce : list(alpha) #
             (alpha # beta -> beta) #
             beta
           -> beta;
--- reduce(nil,f,b)    <= b;
--- reduce(n :: l,f,b) <= f(n,reduce(l,f,b));
```

To use reduce as a replacement for sum we'll need to supply the standard function + as an actual parameter. The word nonop must precede the function + in the parameter list, so the compiler won't try to use it as an infix operator here.

```
reduce([1,2,3],nonop +, 0);
6 : num
```

If we use reduce as a replacement for len, we're not interested in the first argument of the reduction operation because we always add 1 whatever the list element is. Here's a function that ignores its first argument:

```
dec addone : alpha # num -> num;
--- addone(_ , n ) <= n + 1;
```

We use _ to represent any argument we don't want to refer to.

```
reduce("a map they could all understand", addone, 0);
31 : num
```

Like map, reduce is much more powerful than it first appears because the reduction function needn't define a scalar. Here's a candidate that inserts an object into an ordered list of the same kind of object:

```
dec insert : alpha # list(alpha) -> list(alpha);
--- insert(i,nil)     <= i :: nil;
--- insert(i, h :: t) <= if i < h
                           then i :: (h :: t)
                           else h :: insert(i,t);
```

Actually, this isn't strictly polymorphic, as its declaration suggests, because it uses the built-in function <, which is only defined over numbers and characters, but it shows the kind of thing we can do. If we use it to reduce a list of characters,

```
reduce ( "All sorts and conditions of men", insert, nil ) ;
"   Aacddefiillmnnnnnoooorssstt" : list ( char )
```

we'll see that it actually sorts them. The sorting method (insertion sort) isn't very efficient, but the example shows something of the power of higher-order functions and of reduce in particular. It's even possible to use reduce to get the effect of map, but that's left as an exercise for the reader, as they say.

Of course, map and reduce work only on list(alpha), and we'll need to provide different versions for our own structured data types. This is the preferred style of Hope programming because it makes programs largely independent of the "shape" of the data structures they use. Here's an alternative kind of binary tree and a reduce function for it. The tree holds data at its nodes rather than its tips.

```
data tree(alpha) == empty ++
                    node(tree(alpha) # alpha #
                    tree(alpha));
dec redtree : tree(alpha) #
              (alpha # beta -> beta) #
              beta -> beta;
--- redtree (empty, f, b)         <= b;
--- redtree (node(l, v, r), f, b)<=
          redtree(l, f, f (v, redtree(r,f,b)));
```

Here's the Hope version of tree-sort using the new kind of tree and the two kinds of reduce to construct and flatten them. First, a suitable tree-insertion function:

```
dec instree : alpha # tree (alpha) -> tree(alpha);
--- instree (i,empty)      <= node(empty,i,empty);
--- instree (i,node(l,v,r)) <=
             if i<v
               then node(instree(i,l),v,r)
               else node(l,v,instree(i,r));
```

The tree-sort function is now almost trivial to write:

```
dec sort : list(alpha) -> list(alpha);
--- sort(l) <= redtree(reduce(l,instree,empty),
    nonop ::,nil);
sort("Mad dogs and Englishmen");
"   EMaadddegghilmnnnoss" : list ( char )
```

ANONYMOUS FUNCTIONS

When we used map and reduce, we had to define extra functions like fact and square to pass in as parameters. This is a nuisance if we don't need them anywhere else in the program and especially if they're trivial, like sum or addone. For on-the-spot use in cases like this, we can use an anonymous function called a lambda-expression. Here's a lambda-expression corresponding to sum:

```
lambda(x,y) => x + y
```

The symbol lambda serves to introduce the function and x and y are its formal parameters. The expression x + y

(continued)

Hope functions possess "full rights" and can be passed as actual parameters like any data object.

is the function body. The definition is just a recursion equation with => instead of <=. Here's another lambda-expression used as the actual parameter of reduce:

```
reduce( [ "toe","tac","tic" ], lambda(a,b) =>
                              b <> a, nil);
"tictactoe" : list(char)
```

There can be more than one recursion equation in the function definition. They're separated from each other by the symbol |, and pattern matching is used to select the appropriate one. Here's an example that uses pattern matching in a lambda-expression to avoid division by zero when the function it defines is executed:

```
map([1,0,2,0,3],lambda(0) => 0 |
          (succ(n)) => 100 div succ(n));
[ 100,0,50,0,33 ] : list ( num )
```

FUNCTIONS THAT CREATE FUNCTIONS

As we've seen, Hope functions possess "full rights" and can be passed as actual parameters like any data object. It should be no surprise that we're allowed to return a function as the result of another function. The result can be a named function or an anonymous function defined by a lambda-expression. Here's a simple example:

```
dec makestep : num -> (num -> num);
--- makestep(i) <= lambda x => i + x;
```

```
makestep ( 3 ) ;
lambda x => 3 + x : num -> num
```

As we can see from trying makestep, its result is an anonymous function that adds a fixed quantity to its single argument. The size of the increment was specified as an actual parameter to makestep when the new function was created and has become "bound in" to its definition. If we try the new function, we'll see that it really does add 3 to its actual parameter.

```
makestep (3) (10);
13 : num
```

There are actually two applications here. First we apply makestep to 3, then the resulting anonymous function is applied to 10. Finally, here's a function that has functions as both actual parameter and result:

```
dec twice : (alpha -> alpha) -> (alpha -> alpha);
--- twice(f) <= lambda x => f(f(x));
```

Here we're creating a new function that has a single argument and some other function f bound into its definition. The new function has the same type as f. We can see its effect using a simple function like square:

```
twice(square);
lambda x => square(square(x)) : num -> num
```

```
twice (square) (3);
81 : num
```

The new function applies the bound-in function to its argument twice. We can even bind in twice itself, generating a new function that behaves like twice except that the function eventually bound in will be applied four times.

```
twice(twice);
lambda x => twice(twice(x)) :
     (alpha -> alpha) -> (alpha -> alpha)
```

```
twice(twice) (square) (3);
43046721 : num
```

CONCLUSION

You've seen how a Hope program is just a series of functions that are regarded as definitions of parts of a data structure—the "results" of the program—and how the powerful idea of higher-order functions allows us to capture many common program patterns in a single function.

Some of these ideas will already be familiar to users of LISP, but they appear in a purer form in Hope because there are no mechanisms for updating data structures like LISP's SETQ and RPLACA or for specifying the order of evaluation like GO and PROG. Unlike LISP programs, Hope programs are free from side effects and possess the mathematical property of referential transparency.

You've seen features that are primitive or lacking in LISP and in most imperative languages. The data declaration lets you define complex data types without worrying about how they're represented, and pattern matching lets you decompose them, so you can use abstract data types directly without writing access procedures and without the hassle of inventing lots of new names. The typing mechanism lets the compiler check that you're using data objects in a correct and consistent way, while the idea of polymorphic types stops the checking from being too restrictive and lets you define common data shapes with a single function.

Higher-order functions and polymorphic types let us write very concise programs. Programmers are more productive and their programs are easier to understand and to reason about. Referential transparency further improves our ability to reason about programs and makes it possible to transform them mechanically into programs that are provably correct but more efficient in their use of space or time. You can find out more about this by reading John Darlington's "Program Transformation" on page 201. Finally, referential transparency frees the meaning of Hope programs from any dependence on the order they're evaluated in, making them ideal for parallel evaluation on suitable machines. You'll be seeing more of Hope and languages like it in the future. ■

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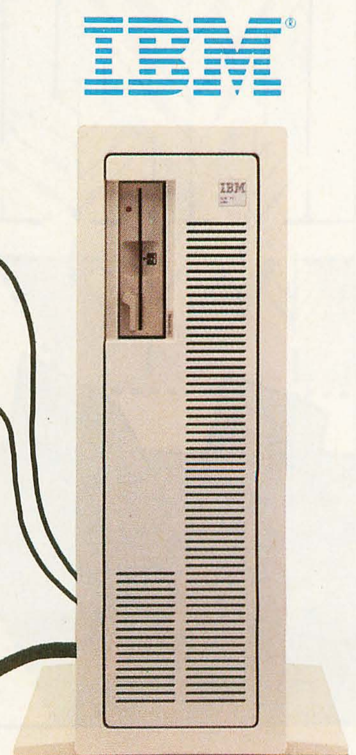
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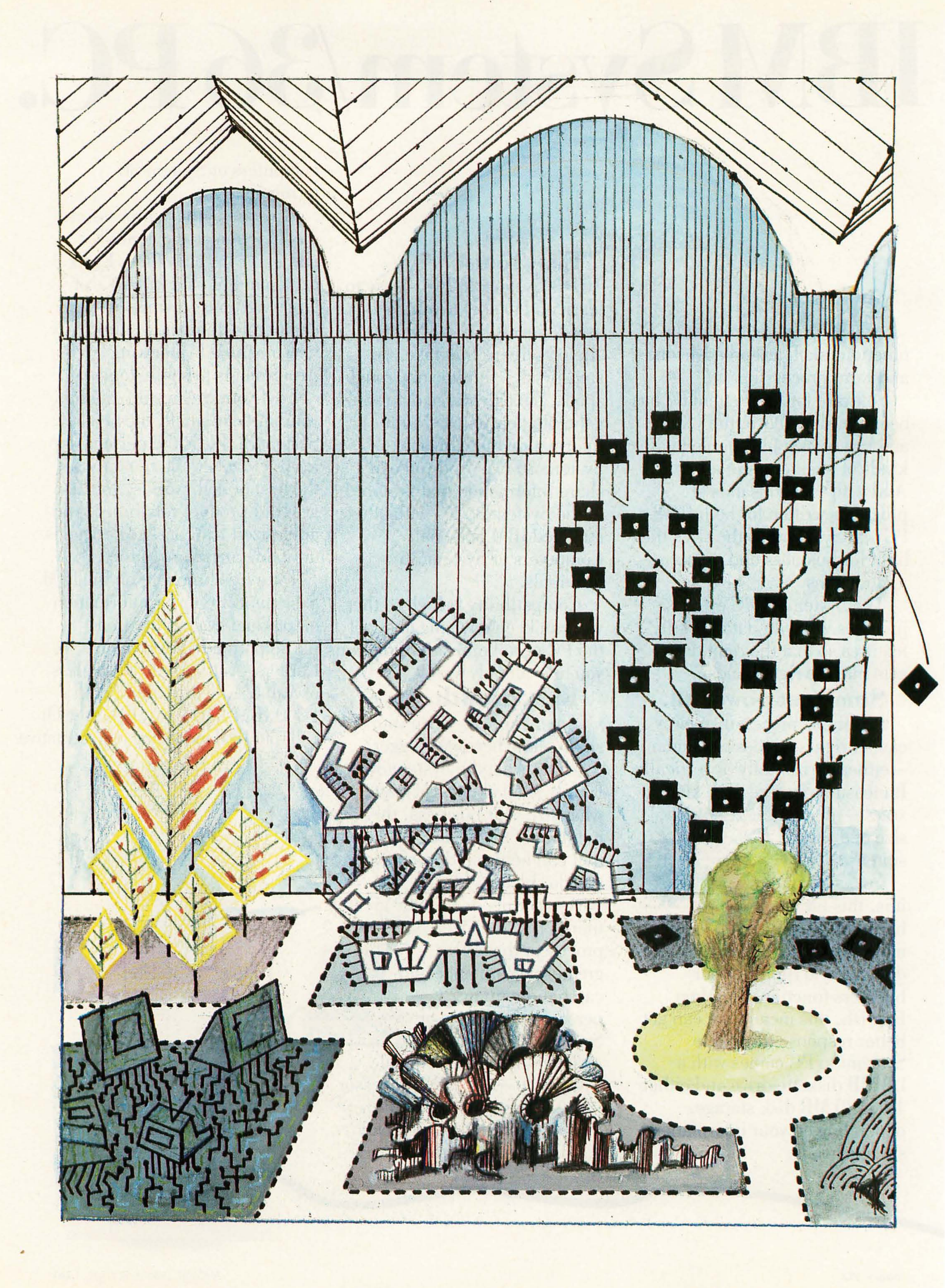
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Reviews

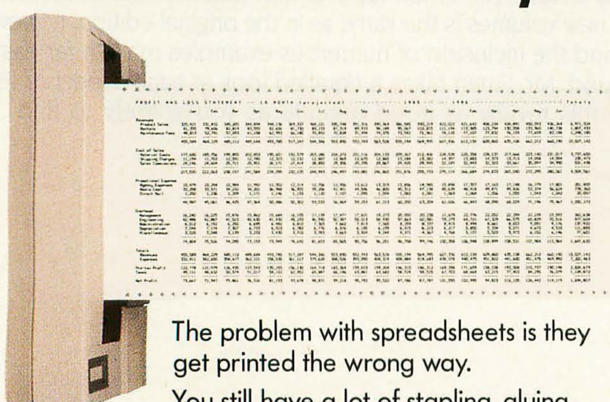
OUR REVIEW OF THE TANDY 1000 focuses on a system that is earning a good reputation for its combination of features and for its relatively low price. In fact, Rich Malloy, our senior technical editor in New York, called to revise the pricing, which had dropped since he had written the review. Now the basic single-floppy system sells for just less than $1000 instead of almost $1200, as originally reported. Prices for systems with either two floppy-disk drives or the 15-megabyte hard-disk drive were correspondingly reduced. While some of its interface characteristics seem to have been consciously modeled after the IBM PCjr (light pen, graphics, and sound), other features (position of primary and secondary drives) remain staunchly Tandy.

Mr. Malloy reports he is generally impressed with the Tandy 1000, especially with its keyboard design. Its layout and feel (and the inclusion of indicator lights) are identical, he says, to the Tandy 2000 and carry on a laudable tradition. A fly in the ointment is the location of the function keys, which tend to crowd the regular numeric keys. Other aspects of the machine show generally logical design and an emphasis on making things easier for, and more accessible to, the user.

Patrick J. Finan notes that while IBM's first Pascal compiler conformed closely to the way the language was first specified, users wanted features that simply weren't there. Such things as good documentation, increased memory access, path names on files, and support of a math coprocessor were on the wish list. With version 2.00 a lot of features have been added, but some are still missing. Furthermore, those that have been added are sometimes not immediately apparent if you're used to version 1.00.

One of the obvious improvements is the fact that the documentation is now about twice as big as before. Mr. Finan reports that much of the information in the first of the two new volumes is the same as in the original edition; however, better organization and the inclusion of numerous examples make it far easier to find your way around. Mr. Finan takes a detailed look at each aspect of IBM Pascal 2.00, making this review as good a guide as you're likely to find.

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R·E·V·I·E·W·E·R'S N·O·T·E·B·O·O·K

Three new systems we received this month have provoked special interest. Each represents a different road for the user—different from each other and different from what most users are already familiar with.

First to arrive was the Epson QX-16. The Epson gives you the choice of MS-DOS, CP/M-80, or an upgraded Valdocs operating system. It has a user-programmable keyboard; two quad-density, 720K-byte floppy-disk drives (that can also be configured as 380K- or 360K-byte drives); 512K bytes of RAM; and both Z80A and 8088 microprocessors. The QX-16 can take three option cards. A green monochrome, bit-mapped, 640- by 400-pixel monitor is standard, as are both serial and parallel interfaces.

First glances indicate this is a nice machine, especially if you're now bound to one type of operating system and software and would like to get the benefit of other programs without abandoning your present library. Getting a full review through the mill is definitely on the boards.

We've encountered several of the new 80286 machines over the past months, mostly at shows and in the hands of software developers. The Kaypro 286i is one of the first production-run hardware units we've seen, however, that is available to users. Even so, there are lags. Ours, for example, came with a notice that its own DOS 3.0 was still under development and that the user should pop in a copy of IBM's PC-DOS 3.0. In a pinch, and with some tweaking, you can even get MS-DOS 2.0 to run. This, however, seems a little like running a Ferrari on economy unleaded.

Kaypro's 286i is a no-bones-about-it IBM PC AT look-alike, right down to the little luggage keys that lock the redesigned keyboard (which should, finally, bring some relief to touch-typists). It also costs less than the IBM PC AT and, so far, seems to have few widely reported problems living up to its advanced billing.

The Ericsson Ergo-Screen Portable gave us one pleasant surprise and a number of pleasant nonsurprises in our cursory prereview look. Primarily, the unit we got has the full-blown 512K bytes of main memory instead of the 256K bytes mentioned as standard equipment in the company's advertisements. It partially compensates for the lack of a second disk drive by letting you configure a RAM disk and run your programs from drive C. I happen to be relatively comfortable with RAM disks in spite of occasional minor disasters. Most people I know are not. Whether or not you feel this is a computer you can use will depend a lot, I suspect, on how you feel about RAM disks.

The gas-plasma screen is certainly more readable than an LCD screen in most lighting conditions. If you really want the screen to stand out, however, you lower the blinds and turn off the overheads. When you cut down the ambient light, the screen background tends to fade into the general gloaming; it's easy to imagine (and see) the gas-plasma characters as simply floating before your eyes. I don't know how I'd care for this effect on a long-term basis, but it has seemed natural, even enjoyable, for the short time I've looked at it.

As with the Ericsson desktop, the Portable's keyboard seems a little light to me and I tend to bounce it around while typing. Unlike the desktop, which is so quiet as to be almost eerie, the Portable establishes a pretty firm background hum (and still seems to get warm). One thing: I have to keep myself from thinking of it as a laptop in spite of its size and shape. Not only do you plug it in to use it, but it weighs about 16 pounds. It is a portable desktop system and, seen from that vantage, is an interesting example of what can be done to alter the standard physical profile of functional, yet mobile, computing resources.

Quite a nice utility for the Macintosh is the TurboCharger from Nevins Microsystems Inc. This is a disk-caching program. The company claims it can increase performance by 500 percent simply because reading a sector from RAM is 500 percent faster than reading it from a disk. The simple brochure that serves as documentation states that normal performance increases of around 200 to 300 percent are more typical. This kind of speed increase for the Macintosh is not to be taken lightly. And indications so far seem to be that it does what it claims with no nasty surprises. I use it with a modified Finder and can get in and out of most programs even faster than what Nevins claims for an average time. On top of that, you can increase performance a little more by buffering your writes in RAM as well as caching program sectors. In this case you get full RAM-disk capability and only save to disk when you eject the disk. Nevins warns against this practice, and I'm not sure the company's wrong to do so. I've used the "buffer writes" function a little; while it increases speed somewhat, it's not much of an increase over what caching will do by itself. If you're at all unsure of your software, you'll probably want to maximize the benefits and minimize the risk. Not that caching is completely safe, either. I accidentally kicked the plug out of the wall socket just after I printed this column and lost the whole thing.

—*Glenn Hartwig, Technical Editor, Reviews*



S·Y·S·T·E·M R·E·V·I·E·W

The Tandy 1000

A low-cost PC-compatible computer

BY RICH MALLOY

When I first heard about the Tandy 1000, I was quite impressed. It seemed to have almost everything I would want in an IBM Personal Computer clone. Plus, it had some of the better features of the PCjr.

For those who haven't seen this machine yet, the Tandy 1000's features include one 360K-byte disk drive (expandable to two, plus one 15-megabyte hard-disk drive), 128K bytes of memory (expandable to 640K bytes), a parallel printer port, interfaces for composite monochrome and RGB (red-green-blue) monitors and a light pen, graphics and sound similar to those of the PCjr, joystick ports, three IBM-compatible expansion slots, a general-purpose collection of software (DeskMate), and a fairly good price ($999). Even a full BYTE configuration (two floppy drives, 256K bytes of memory, monochrome monitor, and serial port) has a reasonable cost ($1746), considering that you get some free software bundled with it.

DESCRIPTION

Since BYTE has published a product description of the Tandy 1000 (see "The Tandy 1000" by G. Michael Vose, December 1984, page 98), I will skip most of the details. Suffice it to say that the system Tandy sent me (two drives, 256K bytes of memory, RGB monitor) fits nicely on my desk and has attracted quite a bit of attention (see photo 1). The system's fan is quieter than that in my IBM PC, and I doubt it will be a disturbance in the office or the home. I have left it on for long periods without noticing it.

The disk drives follow the Tandy tradition of putting the primary A drive below the optional B drive. And while the disk drive latches do not have that feel of quality I have noticed on other machines, the disk drives themselves are fairly quiet and seem to work well.

The machine's general design is logical. The on/off switch is on the far end of the right side of the machine (just like IBM), but many other items are on the front where they are accessible. These include the keyboard and joystick connectors and a red reset button. You access the expansion-board slots through the front as well.

KEYBOARD

Tandy seems to know how to design keyboards. Apparently recognizing a good thing when they see it, Tandy's designers reissued the Tandy 2000 keyboard with hardly a key label changed. The Tandy 1000 keyboard (see photo 2) has the same layout, the same superior feel, and the same welcome relief from the standard clone keyboards that keep appearing on the market. Some of its better features are a separate inverted-T cursor-key layout, a left Shift key and carriage return in the places where you would expect them, indicator lights for the Caps and Num Lock keys, 12 function keys arranged horizontally, and a Hold key. In short, it is one of the better keyboards on the market.

The only aspect of it I don't like is that the function keys are too close to the numeric keys. For example, I sometimes hit the 5 key when I mean to hit F5. Also, if you are accustomed to IBM's vertical function keys, the horizontal arrangement can be confusing. And since some of the keys have different key codes than those on the IBM PC, you might find that in a small number of programs these keys do not work as they should. For example, the XyWrite II Plus word processor does not recognize the Tandy's cursor keys. It looks to the numeric keypad, as on the IBM PC. Fortunately, XyWrite II Plus lets you reconfigure the keyboard as you wish.

DISPLAY

Two displays are available for the Tandy 1000: a green monochrome display ($150) and an RGB display ($550). I didn't get a chance to look at the monochrome display, but the RGB display looks good (see photos 3 and 4). It is IBM PC-compatible and pro-

Rich Malloy is the New York editor for BYTE magazine. He can be reached at BYTE, McGraw-Hill, 43rd floor, 1221 Avenue of the Americas, New York, NY 10020.

duces a fairly sharp picture with good colors. In fact, it has better resolution and color than the $429 IBM display often bundled with the PCjr.

One problem with this display is that the picture is sometimes a bit jumpy, as if it were hypersensitive to power-line noise. Also, the monochrome text characters are not as sharp as those of the IBM PC monochrome adapter, the Compaq, or the AT&T 6300. However, the monochrome display has the capacity to display graphics, and it can even display colors as shades of gray.

INTERFACES

The Tandy 1000 comes with a number of interfaces as standard equipment. These include a parallel printer connector, two joystick connectors, and a light-pen connector. Surprisingly, a serial RS-232C connector is missing; this seems to be another tradition in the TRS-80 Model III/4 family.

I did not try the joystick or light-pen ports, but the printer port seemed to work fairly well. Those readers with a Model III or 4 will be glad to find that the 1000 uses the same 34-pin card-edge connector to Centronics-connector printer cable ($40). I tried this port with a Star Micronics Gemini-10X printer, and it worked fine.

EXPANSION

When it comes to expansion, the good news is that the 1000 has three expansion slots that Tandy claims are IBM PC-compatible. But they are only about 11½ inches long, instead of the usual 13 inches. This is a consequence of the 1000's small footprint. Since all the IBM boards I had were big, multifunction 13-inchers, I had no way of testing how compatible these slots are.

The size of these slots might be a major fault of this system. If your intended use of the Tandy system depends on an unusual expansion board, you should make sure that board will be short enough to fit into the 1000.

Most of the more routine boards are already available from Tandy (e.g., extra memory, serial port, modem). But note that if you fill up the 1000 with a full complement of memory (640K bytes on two boards) and a serial port, all your slots will be in use.

One of the advantages of the IBM PC is the large number of expansion cards available for it. If only a small number of these cards are short enough for the Tandy 1000, Tandy owners might miss out on one of the main advantages of an IBM PC-type system.

I did get a chance to use two boards produced by Tandy. One was a memory board that boosted the Tandy's memory up to 256K bytes. It also included direct memory access (DMA) capability, which speeds up

(continued)



Photo 1: *The Tandy* 1000 *with* RGB *display and two floppy-disk drives.*

the system and helps explain the high price ($300) of this board.

The other board I tested was Tandy's 300-bits-per-second modem board. I admit to a bias against internal modems. An external modem can tell you instantly when you dial a wrong number or the line has been disconnected. That said, I was also disappointed to find that this modem is not Hayes-compatible (it is, of course, Radio Shack–compatible), and none of my software would work with it. The 1000's DeskMate did work but had several problems. My advice is to avoid this board. Get the serial board and a good external modem.

SOFTWARE

The Tandy 1000 comes standard with MS-DOS version 2.11, Microsoft's GW-BASIC, and DeskMate, a simple, integrated software package. This is a pretty good bundle of software, but I had a minor problem with all three packages.

First, the operating system seems to work pretty well. It has all the basic features and, if you want, you can even run IBM PC-DOS 3.0 on the Tandy. The problem is that the documentation overall is very skimpy, worse even than Microsoft's own manual for its operating system. In fact, there was nothing at all in the way of a separate DOS manual. I hope that better documentation will soon be available.

The version of BASIC I received was quite good but incomplete. For example, it enables you to access the Tandy's 16-color graphics, but it would not access the modem port too well. Here again, the manual was a bit skimpy. This is unfortunate, since many people might be using BASIC for the first time on this machine. Tandy has informed me that by the time this article appears, a new complete version of BASIC will be available.

Table 1: *A comparison of the word-processor portion of DeskMate with WordStar 3.3 running on the Tandy 1000. Except for scrolling, DeskMate performs fairly well. Tests were done using a standard 4000-word (22K bytes) document.*

	DeskMate	WordStar
Document load	6.0	5.4
Document save	8.7	27.2
Search for last word	5.1	11.7
Scroll	78	38

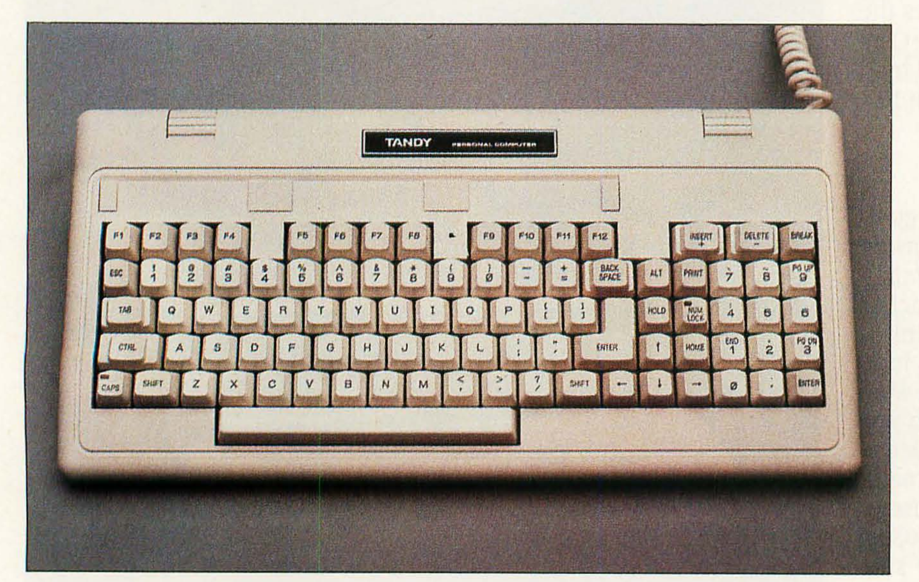


Photo 2: *The keyboard of the Tandy 1000. Note that it is very similar to the Tandy 2000's keyboard.*

DESKMATE

DeskMate is a fairly good software package that has several interesting features. It has a word processor, a database manager, a spreadsheet, a calendar/alarm, an auto-dialer, a communications program, and a bulletin-board program. Unfortunately, the quality of the individual parts might leave some serious users a little disappointed. Most of the parts can be described as fairly good, and some are very friendly. But a few, such as the auto-dialer, are downright ornery. I have yet to get that part of the program to work.

Also, it seems to me that a little extra programming work could have turned DeskMate into a much better program. For example, the Text word processor has most of the features you would expect to find in a word processor and, in fact, is very similar to the text processor on the portable Model 100. To top it off, it is pretty fast (see table 1). But it does not contain a Move command. You have to copy a block of text and then go back and delete the original block.

I have another example. The spreadsheet documentation gives you a formula for amortization payments. This is a laudable idea, but if you try to calculate your monthly payments for a 30-year mortgage, you are in for a surprise. The spreadsheet cannot raise a number to a power greater than 20, and this means that you cannot calculate the payments for any loan longer than 20 months. There is no logical reason why this limitation should exist.

I like a lot of DeskMate's features. I particularly appreciate the menu system that lets you access any document or spreadsheet very easily. But my feeling is that if you intend to do

(continued)

AT A GLANCE

Name
Tandy 1000

Manufacturer
Tandy/Radio Shack
1500 One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

Size
(without display)
16.5 by 13.4 by 5.9 inches

Components
Processor: 16-/8-bit 8088, 4.77 MHz
Memory: 128K to 640K bytes of memory
Mass storage: One or two 360K-byte 5¼-inch floppy-disk drives, MS-DOS format
Monochrome display: Green phosphor, composite video, 80-character by 25-line text, IBM PC-compatible characters; graphics are 640 by 200 pixels with four levels of gray
Color display: IBM PC-compatible RGB; graphics are 640 by 200 pixels with four colors, or 320 by 200 with 16 colors
Keyboard: 90 keys, including four cursor keys, 12 programmable function keys
Interfaces: Parallel printer port

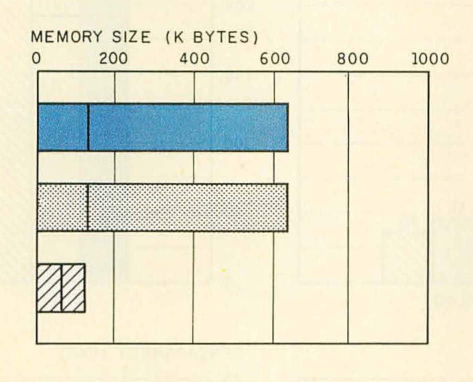
Software
MS-DOS 2.11, GW-BASIC, DeskMate integrated software

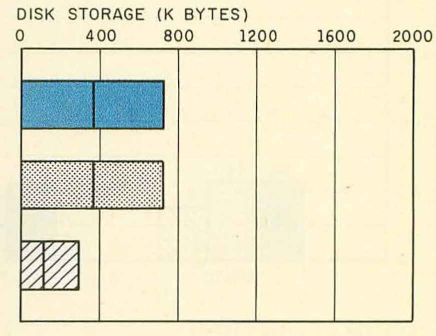
Options
Monochrome display ($150), RGB display ($550), serial port ($99), 256K bytes of memory total ($300), second disk drive ($300), internal 300-bps modem ($180), 15-megabyte hard disk ($2345)

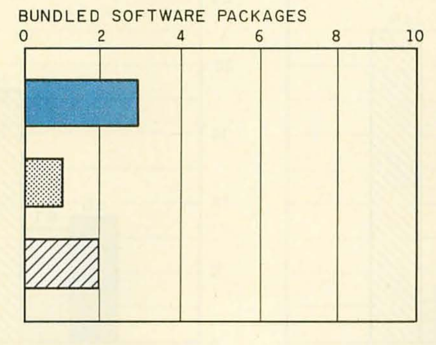
Documentation
DeskMate tutorial (140 pages), DeskMate reference (82 pages), BASIC reference (74 pages)

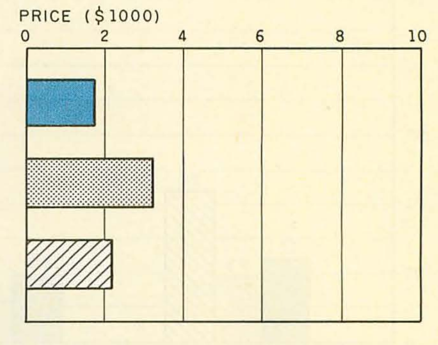
Price
With 128K bytes of memory and one drive: $999
With 256K bytes of memory, two drives, and monochrome display: $1746









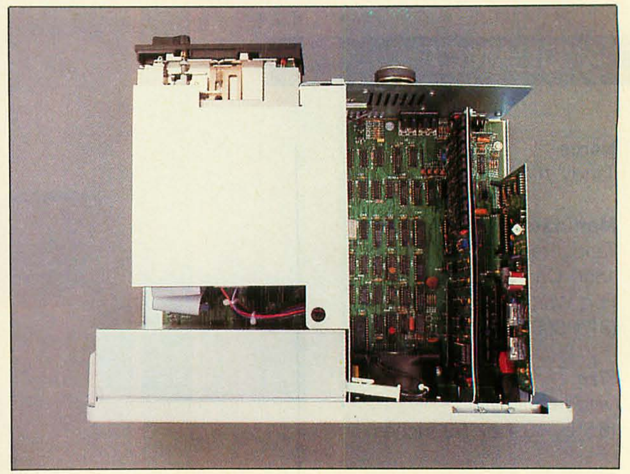


TANDY 1000 IBM PC APPLE II E

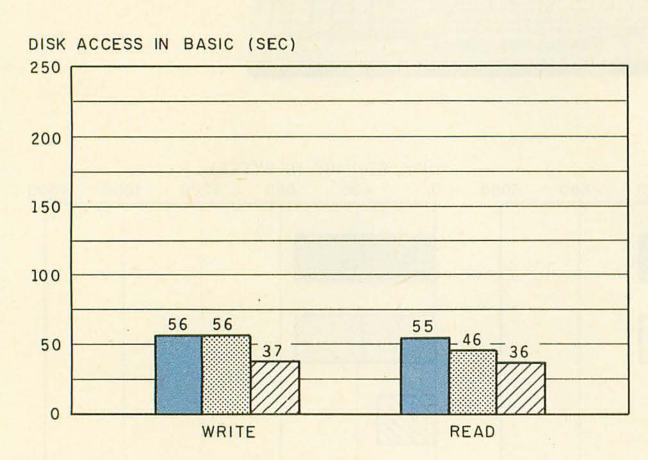
The Memory Size graph shows the standard and optional memory available for the three computers under comparison. The Disk Storage graph shows the highest capacity of one and two floppy-disk drives for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of each system with two high-capacity floppy-disk drives, a monochrome monitor, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), and the standard operating system and BASIC interpreter for each system.

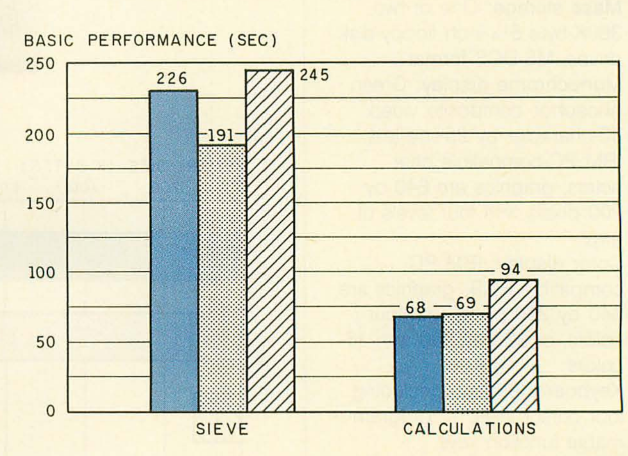


The rear panel of the Tandy 1000. Note the three expansion slots on the right, one of which is occupied by an internal modem.



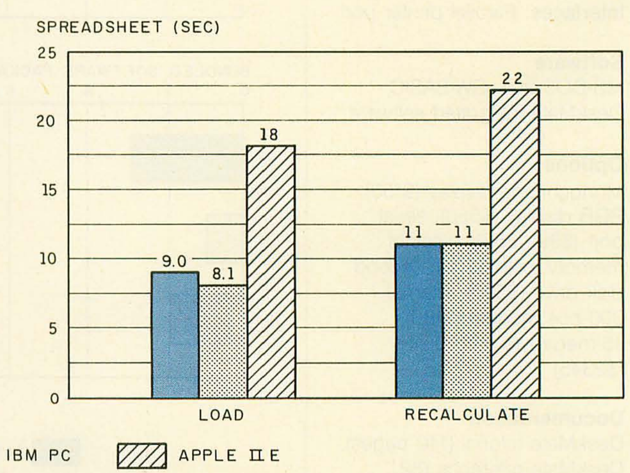
Inside the Tandy 1000. Note the short expansion-card slots.





SYSTEM UTILITIES (SEC)

50
40
30
20
10
0
12
9.6
22
9.9
5.8
45
40K FORMAT/DISKCOPY
40K FILE COPY



TANDY 1000 IBM PC APPLE II E

The graph for Disk Access in BASIC shows how long it takes to write and to read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see June 1984 BYTE, page 327, and October 1984, page 33.) In the BASIC Performance graph, the Sieve results show how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. In the same graph, the Calculations column shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted for 40K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell Microsoft Multiplan spreadsheet where each cell equals 1.001 times the cell to its left. The tests for the Tandy 1000 used MS-DOS 2.11 and GW-BASIC. The tests for the Apple IIe were done with ProDOS. The IBM PC was tested with PC-DOS 2.0 and BASICA.

serious work, you will probably have to purchase one of the good single-purpose software packages, such as pfs:Write, Multiplan, PC-Talk, or dBASE II. Use DeskMate for simple applications and experimentation.

PERFORMANCE

As you might know, the IBM PCjr was not only a bit incompatible with the IBM PC, it was also a bit slower (see "The IBM PCjr" by Rowland Archer Jr., August 1984 BYTE, page 254). My question was: Would the Tandy be as slow as the PCjr or as slow as the PC? I tested the 256K-byte version of the Tandy 1000 with its BASIC interpreter and with Multiplan. I also removed the optional memory board and tried some of the tests again to see if the DMA capability on that board made much of a difference. Finally, I put DeskMate through some standard tests to see how capable it was. The results were interesting.

In the BASIC tests, the Tandy 1000 was as fast as the IBM PC for Disk Write and the Sieve. But it was significantly slower in the Disk Read and Floating-Point Calculations tests, although not as slow as the PCjr. In the System Utilities and Spreadsheet tests, the Tandy was again appreciably slower. However, in one test, the 40K File Copy, the Tandy 1000 was even slower than the PCjr.

When I took out the extra memory board with DMA, I expected some difference in disk access times, but the BASIC tests showed practically no difference. The Spreadsheet tests were appreciably slower: The Spreadsheet Load was 38 percent slower, and even the Recalculate was about 9 percent slower. For some reason, the File Copy was a little faster than it was with the DMA.

I tried to do some tests using the spreadsheet in DeskMate, but this program is not designed for speed. It took DeskMate 75 seconds to recalculate BYTE's standard 625-cell spreadsheet, about seven times as long as it takes Multiplan. The word processor was a different story. DeskMate performed quite admirably with BYTE's standard 4000-word document (see table 1). Except for scrolling, DeskMate was as fast or faster than WordStar 3.3 running on the same machine.

Overall, the Tandy 1000 fares well against the IBM PC. Tandy designers have claimed that, in many tests, the 1000 is actually faster than the IBM, but I saw no evidence of this. However-

(continued)

Photo 3: *Text on the Tandy 1000's RGB display.*

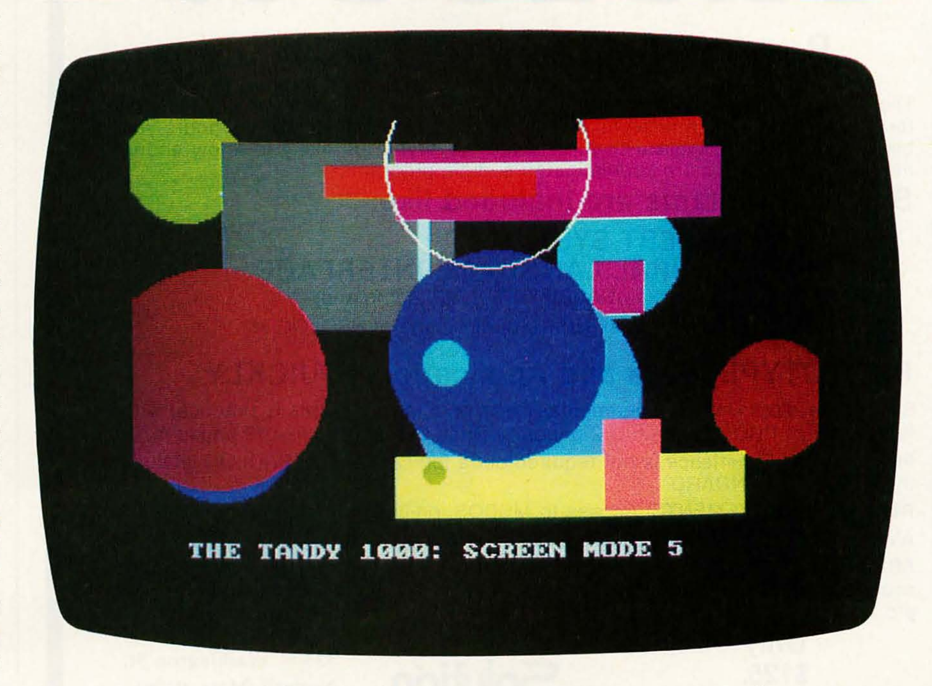


Photo 4: *An example of color graphics on the Tandy 1000's RGB display. Note that in medium-resolution mode (320 by 200 pixels) the monitor can display a total of 16 colors, four times the number available on the IBM PC.*

ever, the 1000 does match the PC on some tests and is not too far behind on the others.

MANUALS

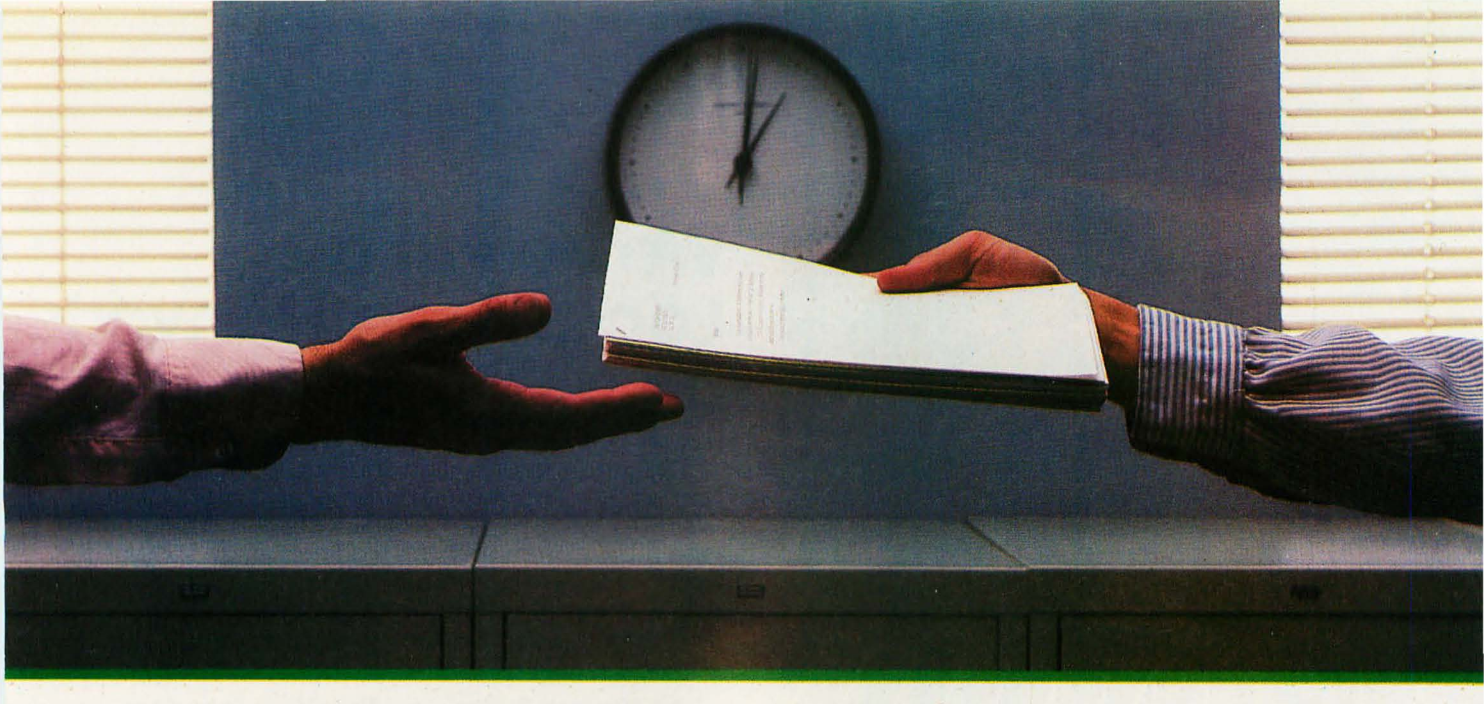
I received three manuals with the system: a DeskMate tutorial that includes information on setting up the computer hardware, a DeskMate reference manual, and a BASIC reference manual. As I mentioned earlier, a DOS manual was nowhere to be seen and sorely missed. Tandy did a nice job with the DeskMate manuals, although some parts of the program are not explained very well. And, of course, a little bit of Radio Shack bias is evident. For example, it would be nice if the writers had included some information about how to set up DeskMate for a non–Radio Shack modem.

The BASIC reference manual has almost everything you really need, but not a sentence more. And some information is missing. For example, it doesn't mention that the INKEY$ command will interpret the cursor keys as 2-byte codes rather than the single-byte codes used for almost every other key.

SUMMARY

The Tandy 1000 seems to be a good, reasonably priced IBM PC clone that has most of the best features of the IBM PC and PCjr. It is compatible with all the IBM software that I have tried. Also, it has three IBM PC-compatible expansion slots, but these slots are too short for most IBM expansion boards. The keyboard is good. And this system seems to have the same superior color graphics and sound capabilities as the PCjr. Its only deficiencies are the above-mentioned short expansion slots, the lack of a high-quality monochrome text font, and an incomplete (as yet) BASIC interpreter.

Of course, the attractiveness of the machine depends to a great extent on its competition. At current prices it is a very good alternative to the IBM PC. I would recommend the Tandy 1000 for all applications that do not depend on special expansion boards or a highly compatible BASIC. ■



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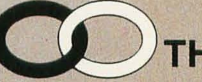
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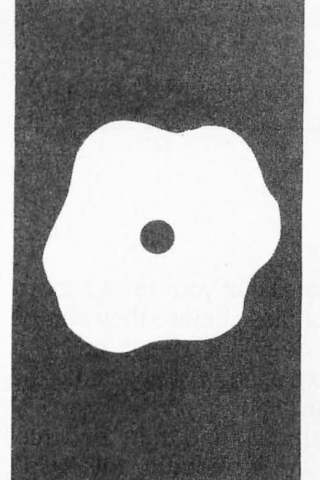
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SOFTWARE REVIEW

IBM Pascal 2.00

This version has many improvements, including better documentation and 8087 coprocessor support

BY PATRICK J. FINAN

Pascal has always been a popular language for developing large, complex applications. Its highly structured nature and strong data-typing capabilities have made it a successful teaching tool and application-development language. While version 1.00 of the IBM PC Pascal Compiler conformed closely to the original Pascal description, most users wanted improvements—better documentation, access to all memory on a machine, the ability to use path names on files, and support of the 8087 math coprocessor. Version 2.00 of the IBM Pascal Compiler offers several new features that greatly extend the product's capabilities. However, not all the changes will be transparent for those moving from version 1.00 to 2.00.

DOCUMENTATION

The first change that an IBM Pascal user will notice in version 2.00 is that the amount of documentation has doubled. The two manuals are well organized and easier to understand than the original manual.

The first book consists of 11 chapters and five appendixes that cover fundamentals. It explains how to use the compiler and describes the major parts of a Pascal program—types, constants, variables, expressions and statements, and procedures and functions. A full chapter treats program structure, units, and modules, and a complete discussion explains how to call assembly-language and FORTRAN routines. This book covers most of the same topics as the original manual, although it has been rewritten to include better explanations and many more examples.

The second book is a language reference guide containing detailed explanations and examples of all the available commands, keywords, procedures, functions, and compiler-directive metacommands.

THE COMPILER

IBM provides a SETUP program that you must run to build your PAS1, PAS2, and library work disks. In building the library disks, you must choose one of three different math modules and one of two DOS interface modules. Selection of the math module is based on whether or not you have an 8087 math coprocessor chip installed. In addition, each library has a different effect on the speed, precision, and size of your executable (.EXE) files.

To use the first module, 8087ONLY, you must have an 8087 math coprocessor installed in the PC. Of the three math modules, 8087ONLY generates the least code, runs the fastest, and produces the highest-precision results.

The REGMATH module will not use the 8087 math coprocessor, even if one is installed and enabled. It generates results of normal precision and is optimized for speed.

The EMULATOR module uses the 8087 math coprocessor if it is present and emulates the device if it is not. If the 8087 is installed, programs run as fast and with as much precision as the 8087ONLY module. If the 8087 is not installed, the program runs much slower but with the same precision as with 8087ONLY. In either case, the run-time modules created are larger than those produced by 8087ONLY and REGMATH.

Thus, if you have an 8087 installed, create the library disk with the 8087ONLY module. Otherwise, you need to consider the level of precision required by the application. Normal-precision applications would probably use the REGMATH module, while extended-precision applications would use EMULATOR.

The compiler comes with a source program called DEMO.PAS that serves as a practice file for users. The manual lists the speed and file-size comparisons for DEMO.PAS using each library module (see table 1).

The DOS interface library modules determine which version of the operating system

(continued)

Patrick J. Finan (10519 Wyscarver Rd., Cincinnati, OH 45241) is a senior systems analyst with a large manufacturing company in Cincinnati. He has a B.S. in electrical engineering from the University of Dayton and an M.B.A. in finance from Xavier University.

AT A GLANCE

Name
IBM PC Pascal Compiler 2.00

Type
Two-pass compiler

Manufacturer
IBM National Distribution Division
1000 Westchester Ave.
White Plains, NY 10604
(800) 426-2468

Format
Three 5¼-inch master disks, not copy-protected

Computer
IBM PC with 160K bytes of memory and two floppy-disk drives or one floppy drive and a hard-disk drive; printer recommended

Documentation
Two manuals

Price
$350; upgrade $100

Audience
Systems and application software developers

your programs will run under. The DOS11 library module lets programs run under DOS 1.10, 2.00, and 2.10. Path names, however, are not supported, since paths were not available in versions before DOS 2.00.

If you select the DOS20 module, your programs can use path names in file specifications at run time but will only run under DOS 2.00 or later. This library module is also required if you want to create code overlays using the LOADER function.

Even though you can create applications that run under DOS 1.10, 2.00, or 2.10, version 2.00 of the compiler only runs under DOS 2.00 or 2.10. You cannot compile programs with version 2.00 of the compiler using DOS 1.10.

REALS AND INTEGERS

Version 2.00 offers two real-number data types—REAL is set equal to REAL4 or REAL8 by the $REAL = n (where n equals 4 or 8) compiler metacommand. REAL4 is a 32-bit representation (1 sign bit, an 8-bit exponent, and a 23-bit mantissa) ranging from 8.43E−37 to 3.37E+38. REAL8 is a 64-bit representation (1 sign bit, an 11-bit exponent, and a 52-bit mantissa) ranging from 4.19E−307 to 1.67E+308.

Unfortunately, IBM has changed the internal storage format of real numbers in version 2.00. This means that you have to convert existing binary data files containing real numbers to the new format before they can be used by programs created with the new compiler. The manual states that you "must convert these data files" before they can be used but does not offer a utility or even an explanation of how to do the conversion.

New arithmetic and transcendental functions are included in the Pascal library to support these higher-precision quantities. Unfortunately, IBM has also renamed many of the version 1.00 transcendental functions, which means you must modify the programs that use them when you upgrade from version 1.00 to 2.00. For example, in version 1.00 the log base 10 function was called LNDRQQ, while in version 2.00 there are two: LDDRQQ for REAL8 numbers and LDSRQQ for REAL4 real numbers.

Version 2.00 has a new data type called INTEGER4, which is a 32-bit integer ranging from −2,147,483,647 to +2,147,483,647. You can use the operators AND, OR, XOR, and NOT on INTEGER4 variables.

DATE AND TIME

Version 2.00 offers four new procedures and function calls that use the system clock. GETDAT and GETTIM return the date and time components as integer values. SETDAT and SETTIM let you set the system date and time from Pascal by specifying the integer components.

When prompted for library names by the linker, you must specify the library IBMPAS.LIB. These routines eliminate the processing required to extract one component of the date or time from the traditional string for-

(continued)

Table 1: *A comparison of speed and file size for* DEMO *using each of the library modules:* 8087ONLY, REGMATH, *and* EMULATOR.

Math Module	Execution Time	File Size
8087ONLY	9.26 seconds	25,138 bytes
REGMATH	26.25 seconds	28,918 bytes
EMULATOR (without 8087)	36.18 seconds	31,842 bytes
EMULATOR (with 8087)	9.26 seconds	31,842 bytes

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Giving shape to imagination.

mats. The procedures DATE and TIME are still available for situations where the string representations are more useful.

SYSTEM INTERFACES

Several new system-related functions and capabilities should make programming easier and eliminate the need for many assembly-language subroutines. The DOSXQQ function lets you call DOS functions directly from Pascal (via interrupt 21 hexadecimal). This function was available in version 1.00 but was totally undocumented and almost impossible to use. The function parameters pass values to the AX and DX registers. You can use the external variable CRCXQQ to specify the desired value of the CX register. After you invoke the DOSXQQ function, it returns the AL register as its return value and loads the value of the CX and DX registers into the external variables CRCXQQ and CRDXQQ. The declarations of the external variables and the function syntax are as follows:

```
VAR [EXTERN] CRCXQQ,CRDXQQ:
  WORD;
FUNCTION DOSXQQ(AX,DX:
  WORD):BYTE; EXTERN;
```

The major limitation of the DOSXQQ function is that it only uses the AX, CX, and DX registers, while most DOS function calls use additional registers.

A more general way to access DOS function calls is with the procedure INTRP, which lets you execute any software interrupt directly. The format of the call is

```
INTRP (intnum, inregs, outregs);
```

The software interrupt number to be performed is intnum, while inregs and outregs are special variables of the type REGLIST that contain the register and flag values before and after you invoke the interrupt. The data definition for REGLIST is included in a special file called IBMINTRP.INT that must be included in your source file. Listing 1 shows how to declare and use the INTRP function. Again, you must specify the IBMPAS.LIB library when the linker prompts you for

Listing 1: *Program segment showing how to declare and use the* INTRP *function. This function lets you access* DOS *function calls.*

```
(*$INCLUDE: 'IBMINTRP.INT'*)

PROGRAM INTRPDEMO (INPUT,OUTPUT);
  USES IBMINTRP;

VAR
     INREGS,OUTREGS:REGLIST;
     ROW,COL:BYTE;

BEGIN {INTRPDEMO}

.
.
.

     INREGS.AX := 16#0300;              {REQUEST CURSOR POSITION}
     INREGS.BX := 16#0000;              {DEFAULT PAGE}

     INTRP(16#10,INREGS,OUTREGS);      {INVOKE VIDEO INTERRUPT X'10}

     ROW := HIBYTE(OUTREGS.DX);         {CURSOR ROW NUMBER      }
     COL := LOBYTE(OUTREGS.DX);         {CURSOR COLUMN NUMBER}

.
.
.

END. {INTRPDEMO}
```

Listing 2: *This program is an example of how to use the* LOADER *function to bring in code overlays.*

```
PROGRAM MAIN(INPUT,OUTPUT);

VAR

     SELECTION:CHAR;
     RETVAL:WORD;

FUNCTION LOADER (CONSTS MODULE NAME:STRING) : WORD; EXTERN;

PROCEDURE ADD; EXTERN;
PROCEDURE CHANGE; EXTERN;
PROCEDURE DELETE; EXTERN;
PROCEDURE LIST; EXTERN;

BEGIN
     SELECTION := ' ';
     WHILE SELECTION <> 'E' DO
     BEGIN
          WRITELN(OUTPUT,'Enter the desired function -  (A)dd');
          WRITELN(OUTPUT,'                              (C)hange');
          WRITELN(OUTPUT,'                              (D)elete');
          WRITELN(OUTPUT,'                              (L)ist');
          WRITELN(OUTPUT,'                              (E)nd');
          READLN(INPUT,SELECTION);
          CASE SELECTION OF
           'A': BEGIN
                RETVAL := LOADER ('MOD1.OVL');
                IF RETVAL = 0
                  THEN ADD
                  ELSE ABORT('UNSUCCESSFUL LOAD OF MOD1',RETVAL,0);
                END; {CASE OF A}
```

```
        'C': BEGIN
             RETVAL := LOADER ('MOD2.OVL');
             IF RETVAL = 0
               THEN CHANGE
               ELSE ABORT('UNSUCCESSFUL LOAD OF MOD2',RETVAL,0);
             END; {CASE OF C}
        'D': BEGIN
             RETVAL := LOADER ('MOD3.OVL');
             IF RETVAL = 0
               THEN DELETE
               ELSE ABORT('UNSUCCESSFUL LOAD OF MOD3',RETVAL,0);
             END; {CASE OF D}
        'L': BEGIN
             RETVAL := LOADER ('MOD4.OVL');
             IF RETVAL = 0
               THEN LIST
               ELSE ABORT('UNSUCCESSFUL LOAD OF MOD4',RETVAL,0);
             END; {CASE OF L}
        'E': WRITELN(OUTPUT,'End of Program');
        OTHERWISE;
      END; {CASE OF SELECTION}
    END; {WHILE}
      END. {MAIN}
MODULE MOD1;
PROCEDURE ADD;
      BEGIN
        WRITELN(OUTPUT,'This is the ADD function');
    END;
END. {MOD1}
MODULE MOD2;
PROCEDURE CHANGE;
      BEGIN
        WRITELN(OUTPUT,'This is the CHANGE function');
    END;
END. {MOD2}
MODULE MOD3;
PROCEDURE DELETE;
      BEGIN
        WRITELN(OUTPUT,'This is the DELETE function');
    END;
END. {MOD3}
MODULE MOD4;
PROCEDURE LIST;
      BEGIN
        WRITELN(OUTPUT,'This is the LIST function');
    END;
END. {MOD4}
```

A useful function, LOADER, lets you break up large programs into a main routine and one or more code overlays.

library names.

While INTRP appears to be a more universal approach, you should remember that it must load and store all the registers. Time-critical applications should use DOSXQQ if they require only the AX, CX, and DX registers. Otherwise, you might still need an assembly-language routine.

The routines INP and OUTP let you read and write information directly to a specific hardware port address. This might be used to read the game paddles or set the mode on the monitor cards. You must include the file IBMPORT.INT at the top of the program, and a USES IBMPORT must follow the program declaration. You must also specify the library IBMPAS.LIB to the linker.

A new data attribute called ORIGIN lets you locate a variable at a specific memory address. This makes the job of looking at system data areas easier. They are defined by specifying both the segment base and offset of the variable. For example, you could use the following definition for a word variable that contains the bit mask of the keyboard status:

```
VAR KEYSTATUS [ORIGIN
    16#0040:16#0017] : WORD;
```

PROGRAM OVERLAYS

Another new and useful function, LOADER, lets you break up large programs into a main routine and one or more code overlays. As the main program executes, it can bring in one overlay at a time. You must explicitly load the overlay before any of the

(continued)

```
PAS1 MAIN.PAS,,;
PAS2

PAS1 MOD1.PAS,,;
PAS2

PAS1 MOD2.PAS,,;
PAS2

PAS1 MOD3.PAS,,;
PAS2

PAS1 MOD4.PAS,,;
PAS2

MKOVL MOD1

MKOVL MOD2

MKOVL MOD3

MKOVL MOD4

LINK PLOADER + MAIN + MOD1 + MOD2 + MOD3 + MOD4, MAIN,,;
```

Figure 1: *How to compile and link the overlay program of listing 2.* MKOVL.COM *marks the specified object file as an overlay.* PLOADER.OBJ *performs the loader function and is included as the first object in the link process.*

```
LIB PASCAL.LIB + NEWPROC;    {adds NEWPROC.OBJ to library}
LIB PASCAL.LIB - OLDPROC;    {erases OLDPROC from library}
LIB PASCAL.LIB * OLDPROC;    {removes OLDPROC from the library and }
                             {places it in a file named OLDPROC.OBJ}
```

Figure 2: *How the library manager modifies* PASCAL.LIB.

procedures and functions defined in that overlay can be called. An overlay routine can call procedures and functions defined in the main routine, but it cannot call routines that are part of another overlay. The main program requests the code overlay by issuing the command

```
RETVAL := LOADER
  ('drive: \ path \ filename.OVL');
```

If the load is successful, RETVAL is zero and the overlay's procedures and functions are available until the next overlay is performed. Otherwise RETVAL contains the error code. Listing 2 shows an example of a program using overlays. [*Editor's note: Listing 2 is available as* OVERLAYS.PAS *for downloading via* BYTEnet *Listings. The telephone number is* (617) 861-9774.]

Two special files on the PAS1 disk handle overlays. MKOVL.COM marks the specified object file as an overlay. PLOADER.OBJ performs the loader function and is included in the LINK command as the first object file of the list. Figure 1 shows how you use these two files. After you compile all five source-code files individually using PAS1 and PAS2, you run MKOVL.COM on the four overlay files and link them together. The final result is a file called MAIN.EXE; the four overlay modules have the file extension "OVL".

Dynamic Memory Allocation

One of the most useful features of Pascal is the ability to dynamically allocate variables in an area called the heap. Version 1.00 of the IBM Pascal Compiler used ALLHQQ, NEW, and DISPOSE to manage the heap. This area (64K bytes maximum) is shared between constant, stack, and heap data. Version 2.00 has a new function called FREECT that returns the space

REVIEW: IBM PASCAL 2.00

Listing 3: *A program segment that shows how to build a name and address list on the long heap.*

```
PROGRAM HEAPTEST (INPUT,OUTPUT);
TYPE
    LONG PTR = ADS OF MAIL LIST;
    MAIL LIST = RECORD
        NAME    : STRING (20);
        ADDRESS : STRING (25);
        CITY    : STRING (15);
        STATE   : STRING (2);
        ZIP     : STRING (9);
        NEXT    : LONG PTR;
    END;
VAR
    NEWPTR : LONG PTR;
FUNCTION GETMQQ (BLKSIZE:WORD):LONG PTR; EXTERN;
PROCEDURE DISMQQ (ADDRESS:LONG PTR); EXTERN;
BEGIN {HEAPTEST}
    .
    .
    .
    NEWPTR := GETMQQ(SIZEOF(NEWPTR^)); {allocates heap variable}
    .
    .
    .
    DISMQQ(NEWPTR); {frees heap variable}
    .
    .
    .
    END. {HEAPTEST}
```

remaining in this area (called the short heap in version 2.00).

In addition to the short heap, version 2.00 has another area called the long heap that starts in memory above the short-heap data area and extends up to the total memory on the machine (minus the space used by DOS). The routines GETMQQ and DISMQQ allocate and free memory blocks from the long heap. The only difference between these routines and the short-heap routines is that the pointer variable used is a 32-bit value (segment:offset) rather than a 16-bit value. You define the 32-bit pointer by using the built-in segmented data type. For example, listing 3 shows how to build a name and address list on the long heap.

Library Manager

Another useful improvement over version 1.00 is the addition of a library manager. The operations you can perform include adding, erasing, and replacing of modules in a library. Figure 2 demonstrates how you might modify PASCAL.LIB.

In addition to changing existing libraries, you can create new ones. To create a new library called MYLIB, you could issue the command

```
LIB MYLIB + PROC1 + PROC2 +
  PROC3 + . . . + PROCn;
```

Conclusion

The benefits of the new compiler far outweigh its few problems. The list price for version 2.00 of the IBM PC Pascal Compiler is $350. Current owners can upgrade to version 2.00 for $100 by sending a copy of the receipt for version 1.00 and an upgrade order form to IBM. Upgrade order forms are available at most stores that carry IBM equipment. ■

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DESKPRO GRAPHICS

In general I agree with Jerry Grady's review of the Compaq Deskpro (May, page 260). I have had a Model 2 for many months and find it reliable, compatible, and fast. But I believe you've overlooked a significant area of incompatibility.

The Deskpro has improved video functions and incorporates both monochrome and color graphics ability, but it will not accept common IBM graphics boards like the Hercules graphics card. This is a disappointing limitation if you want to take full advantage of the graphics ability of programs like Microsoft Word or Lotus 1-2-3.

I have called Compaq, Hercules, and AST Research, and none can offer any help or hope. Had I realized that I would not have access to improved graphic resolution on the Deskpro, I might have chosen a more compatible machine.

BRYAN MUMFORD
Summerland, CA

INSIGHT

Bruce D'Ambrosio's software review of Level 5 Research's Insight expert-system shell (April, page 345) misses the point on the utility of expert systems as assistants in general and the ability of the Insight shell to serve this purpose in particular.

Artificial-intelligence expert systems might have been born in educational institutions, but they are now being developed by many engineers in government and industry. Engineers are the ones who are putting the theory into practice. Further, we are finding important applications for this type of software that do not require the large efforts, funds, and research typical of the systems coming from the academic community.

Insight is a most useful and reasonably priced tool for small-domain knowledge bases. Almost all the limitations Mr. D'Ambrosio describes have work-arounds that you learn from experience with the software. This is no different from any other commercial software. The fact that Insight (like several other expert-system shells) does not support closed-form mathematics is being adressed in an enhancement now undergoing beta testing. However, expert systems used as assistants for advisory or diagnostic purposes in many cases do not require closed-form mathematics.

PHIL CHAPMAN
La Crescenta, CA

I reviewed Insight, not in comparison to mainframe or LISP machine–based research systems, but according to my estimate of what should be possible on a personal computer. I believe that the ability to include variables in rules and to use simple arithmetic are essential in any general-purpose knowledge-based system shell.

Of course, you can often work around limitations, and they might not even cause problems in any one application. However, the development teams for TI's Personal Consultant, Teknowledge's M.1, and Artelligence's OPS5+ feel that both variables and arithmetic are important enough to include in their systems. While these packages all cost substantially more than Insight, Topsi, a $75 variant of OPS5+ from Dynamic Master Systems, also provides both facilities.

I am glad to hear that arithmetic computation capability is being incorporated into a future release of Insight. Also, I consider variables somewhat analogous to arrays in a procedural programming language. I imagine that you don't use arrays in every program you write; you may not even use them often. But once you learn about them, would you buy a compiler that didn't support some kind of array construct?

I am glad to hear that you are successfully using Insight. Insight is not a bad system; I just don't think it is representative of all that could be done on a PC.

—BRUCE D'AMBROSIO

HARDWARE BENCHMARKS

You need to rethink your policy regarding comparison charts in hardware reviews. You constantly compare micros to the IBM PC and Apple IIe, regardless of how appropriate that is. For example, in the March issue (page 247) you compare the $8990, 10-MHz, 8086 Altos 586 to the $3200, 4.77-MHz, 8088 IBM PC and the $2100, 1-MHz, 6502 Apple IIe. Really, shouldn't you compare it to the IBM PC AT and the Stride? Then you have the $1240, 1.79-MHz, 6502C Atari 800XL up against the PC and IIe (page 267). Shouldn't that be the Apple IIc, not IIe? And wouldn't the Commodore 64 be more realistic than the IBM? You should be making comparisons to a given machine's real competition.

It looks as if you use charts with the IBM PC and Apple IIe because it is convenient to do so, not because any thought goes into selecting the comparisons. So next time, compare apples to apples, oranges to oranges, and Osbornes to Kaypros.

RICK DOWNER
Seattle, WA

The purpose of our benchmarks and "At a Glance" boxes is to offer comparisons between the system under evaluation and other systems with widely known capabilities. By consistently using products with known performance characteristics, we intend to provide benchmarks that most readers can interpret in terms of their own experiences with familiar machines and software.

Comparing a new product only against a look-alike or work-alike product has drawbacks. That type of comparison puts the reader in a technological game of musical chairs: The music stops every time any company updates or announces a new product. Relatively few people have resources great enough to permit them experience with a wide selection of expensive equipment.

We are not in the business of predetermining which machines are each other's appropriate competitors.

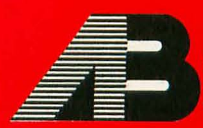
—GLENN HARTWIG
Technical Editor, Reviews

THE HP 110

In reference to Manly W. Mumford's letter in Review Feedback (March, page 303) regarding Ezra Shapiro's review of the HP 110 (June 1984, page 111), I'd like to say that I have been very pleased with the HP 110's capabilities, apart from the need for good lighting conditions. In fact, a whole

(continued)

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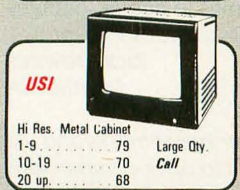
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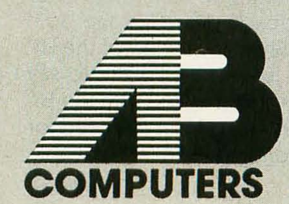
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range of screen-control functions are built into the computer, irrespective of programming language, and you invoke them with escape sequences. The owner's manual appendix D-6 to D-9 lists these sequences, but note that the "toggle caps" sequence should read

ESC &k{0,1}P

To use these within, say, Microsoft BASIC, simply program a statement to print the relevant escape sequence. I usually create user-defined functions at the start of my programs to simplify often used sequences. For Mr. Mumford's benefit, the sequence for screen clear is ESC [2J. You can program this as PRINT CHR$(27) + "[2J" where CHR$(27) is the ASCII code for the escape key.

One disappointment is the omission of graphics-control sequences. These are available either using GW-BASIC or from the HP 110 programmer's toolkit. The basic graphics sequences (circle, line, etc.) could have been included. After all, the HP 150 has these as standard.

D. HARPER
Stockton-on-Tees, Cleveland County, England

MULTIMATE

The repagination problem in MultiMate to which CJ Puotinen (November 1984, page 287) and several letter writers thereafter alluded has been fixed. It's a pity to see this fine program criticized because of one bug in an early version. I used MultiMate 3.22 for multipaged articles for months without difficulty repaginating. Occasionally I had to remove a misplaced format line. I have never lost text, either. The current version (3.30) is even better, since it lets you keep the format lines attached to either text or pages.

The slight backup inconvenience to which Maureen Fleming referred (April, page 348) is also altered in version 3.30. The user can now back up the document automatically if he or she wishes to do so. This was a fix for a nonexistent problem, since all you had to do was copy the document to another disk. You could do this easily either from DOS or from within MultiMate itself.

ROBERT JACOBS
Ellensburg, WA

MT 160 PRINTER

I recently read Mark J. Welch's review of the Mannesmann Tally MT 160 printer (February, page 325) and felt I must comment. I am a data communications technician for the Washington State Patrol–administered ACCESS (A Central Computerized Enforcement Support System).

All our remote terminals (over 250 of them) use MT 160s exclusively, and I would be happy to replace them with something better (and cheaper). After directing about 10 operators throughout the state in reprogramming the printers' parameters after an electrical storm, I would rather have DIP-switched parameter setting. Irregular line voltage and other power-line disturbances play havoc with this otherwise convenient arrangement. Having to run through the complete menu every time this happens is tedious.

On the other hand, the printer is physically well built and prints without much complaint at the workload. The three in our communications center operate without serious problems 24 hours a day. Our State Patrol avoids the problem of hard-to-get and expensive ribbons with reinking equipment. I have no data on how long an individual ribbon lasts, but I have not seen a new one come through here for a long time, and we use more ribbons than anyone else in the state.

MICHAEL L. CLARK
Olympia, WA

ITT XTRA

Having purchased an ITT XTRA last year, I have a few comments to add to John D. Unger's review (April, page 338). I'm not a professional programmer and have had no prior experience with micros, but I've had little difficulty in upgrading our XTRA with IBM-specific hardware. Unlike the PC, the XTRA does not require 256K bytes on the motherboard before you add extra memory.

I popped for IBM PC-DOS 3.0 and abandoned ITT DOS (2.11). I've not found any incompatibilities in the IBM PC versions of software we use. The only software incompatibility discovered so far is ITT BASIC's local field statement elucidated in Melvin Duke's letter to BYTE (March, page 434).

Prospective owners should purchase ITT's technical reference manual for the diagnostics and in the event that the machine must be repaired by technicians unfamiliar with it. Taking into account the superior keyboard, smaller footprint, larger tilt-swivel monitor, and other engineering features, I wouldn't trade our XTRA for a fully loaded PC XT.

GEORGE BRIDGFORTH
Dallas, TX

(continued)

I read John D. Unger's article on the ITT XTRA with disbelief. In July of 1984 I purchased an ITT, initially for word processing with the intention of using it for other applications later.

My original choice of software was Microsoft Word without the mouse. However, when I used Word, the computer slowed to a snail's pace. The monitor would show only a fraction of the characters input from the keyboard. The salesperson couldn't explain the problem but replaced the package with Satellite Software's WordPerfect.

Initially WordPerfect's performance was satisfactory on short documents. However, when the length of the documents and the amount of formatting increased, the system froze with a "RAM parity check error" displayed. The salesperson spent several days calling ITT and Satellite Software. Both companies assured him that there was no problem with using the IBM version of WordPerfect on the ITT XTRA.

At this point, my $3300 package of equipment would not work. Technicians checked the processor and found no problems. The salesperson was in the uncomfortable position of having sold a machine that was allegedly IBM-compatible but would not run two popular word-processing packages. In order to keep me happy, the dealer bought back my XTRA at full credit toward a computer of my choice. I selected an AT&T and have had no problems.

TERRY L. BRINK
Pittsburgh, PA

JUKI 6100

The Juki 6100 printer reviewed by G. Michael Vose in BYTE (August 1984, page 305) has a number of problems that severely limit its usefulness. Letter spacing is irregular, the ribbon doesn't advance properly, and with the add-on tractor unit it's impossible to print lines parallel to one another. Juki's service department has not returned my dealer's repeated calls.

The irregular letter-spacing problem seems insoluble—it has to do with the mechanism for shifting the print head across the page.

The Juki 6100 has two ribbon problems. First, a toothed wheel on the take-up side is supposed to engage the ribbon and draw it onto the take-up spool. At the start of a new ribbon, the toothed wheel frequently exerts insufficient pressure, and the ribbon doesn't move. However, if you turn the take-up spool manually for a page or so, the ribbon eventually advances on its own. The second problem is that the ribbon-advance mechanism is incapable of using all the ribbon. It always jams, leaving twenty or thirty feet of ribbon unused.

The last problem is with the add-on tractor unit. I had to wait two months to get it. When it arrived, it was incapable of printing lines horizontally. One line slanted in one direction, and the next line slanted in the opposite direction. After a short time, I managed to identify the problem: The paper-advance mechanism consists of a pair of gear wheels and a ribbed plastic band. Unfortunately, this ribbed band is only ⅛ inch wide. However carefully it is adjusted, it's incapable of advancing the paper without stretching. The result is that the lines slant.

DAVID LEWISTON
Kihei, HI

MT SPIRIT 80

I have to agree with Shel Kagan's comments in Review Feedback (April, page 348) regarding the Mannesmann Tally Spirit 80 review (November 1984, page 335). I'd also like to point out that the Spirit 80 takes only ribbon cartridges that you can't reink and that are expensive, are hard to find, and provide good impressions for about three weeks of moderate use.

Mannesmann Tally estimates print head life at 30 million characters—not long compared to most print heads. And this one does not seem to stand up well in graphics mode. I have had two heads fail within 15 months while printing graphics (new heads cost $65 each).

The printer now needs repair at an estimated cost of $150.

Spend another $150 on this printer? Thanks, but I'll get an Epson.

RICK GOULIAN
New York, NY

REVIEW FEEDBACK is a column of readers' letters. We welcome responses that support or challenge BYTE reviews. Send letters to Review Feedback, BYTE Publications, POB 372, Hancock, NH 03449. Name and address must be on all letters.

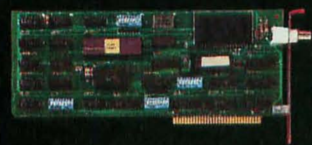
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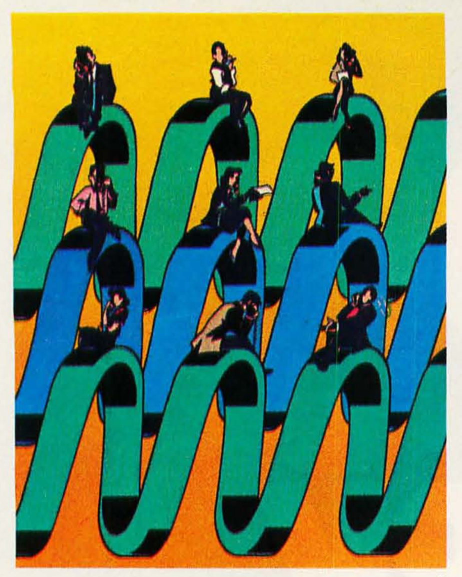


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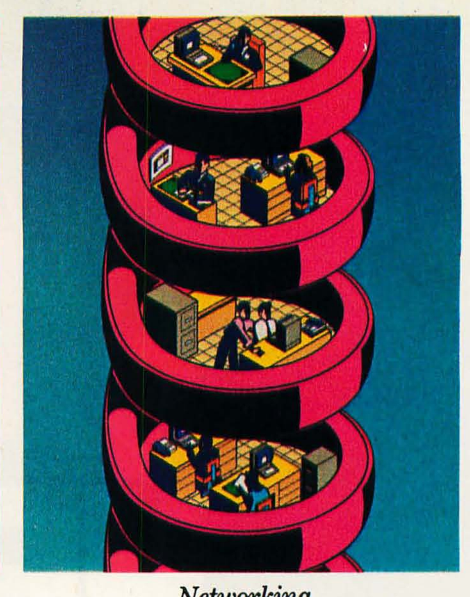


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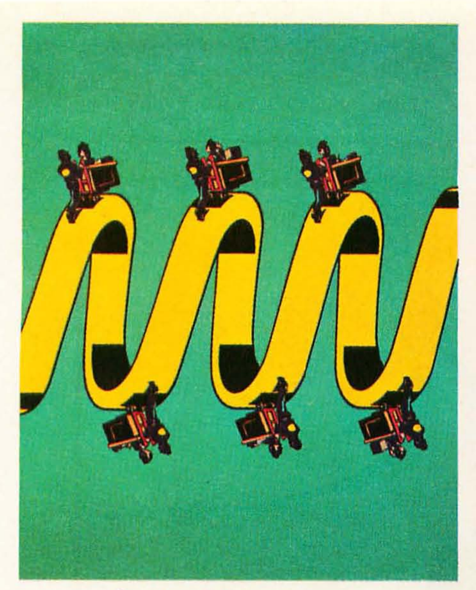
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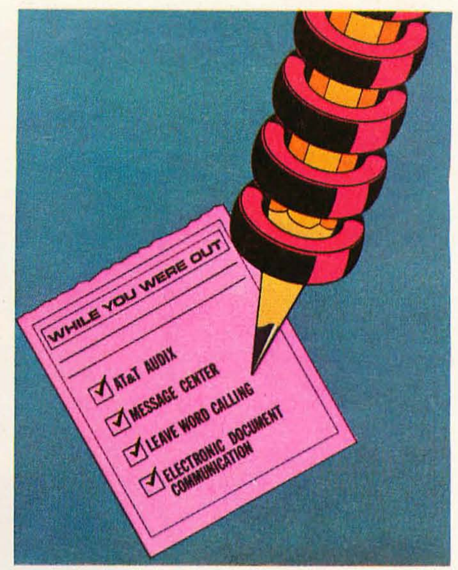
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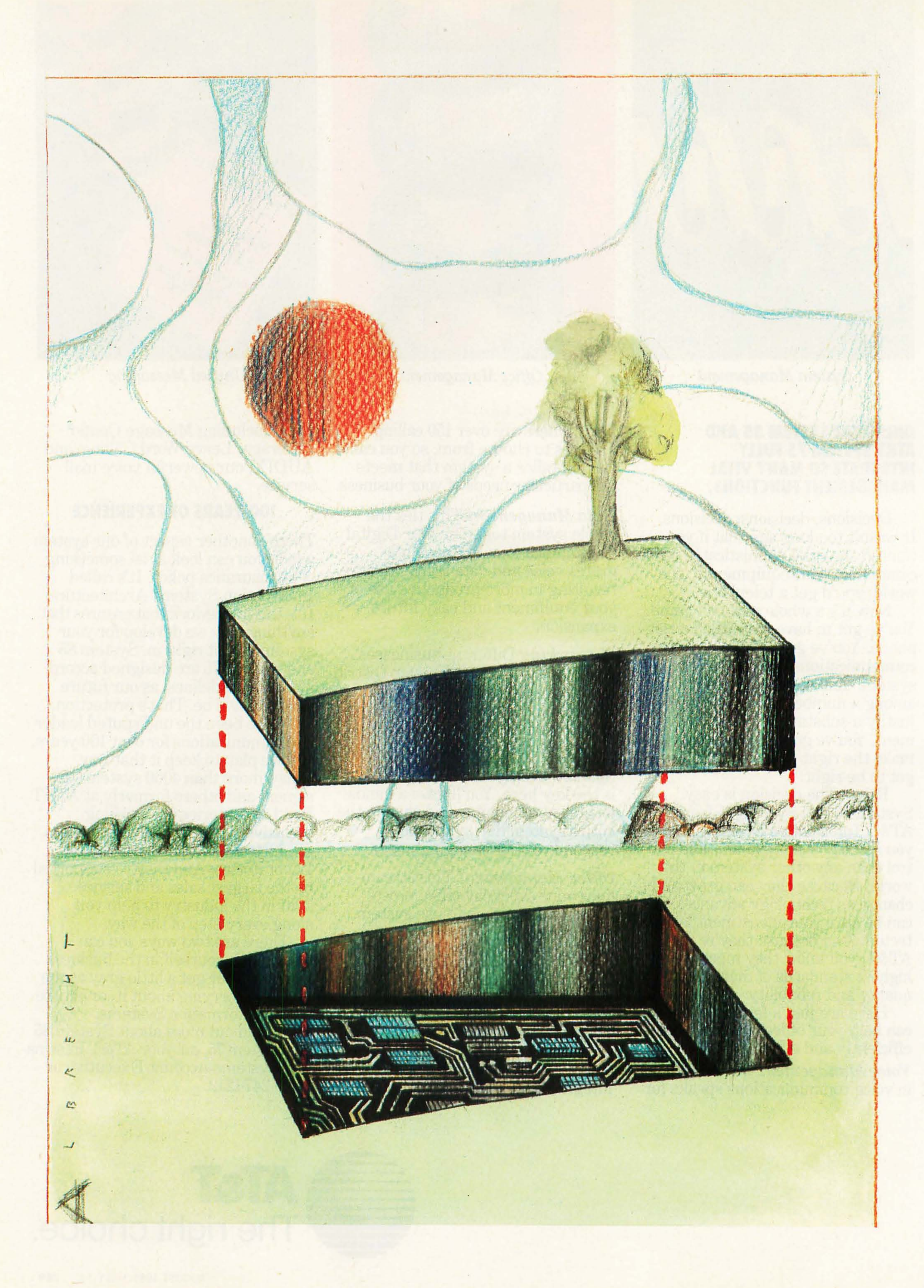
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ALBRECHT

BYTE

Kernel

DUE TO A HEAVY schedule, Jerry Pournelle went to this year's West Coast Computer Faire only because of a commitment to give a talk. However, he's happy that he decided to make the trip. He discovered that the magic is still there, met old friends, and saw many new products.

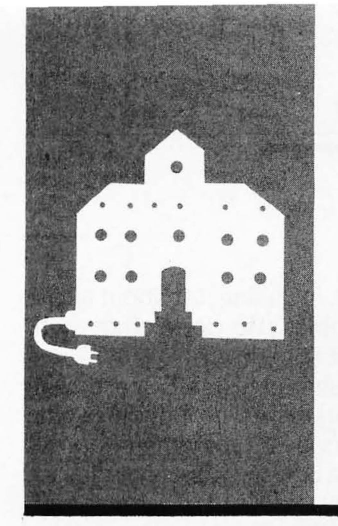
Bill Raike attended the first-ever COMDEX in Japan this spring and found several interesting products on display. He describes the "anonymous" Fujitsu lap-size portable, several laser printers, the latest addition to the NEC PC-9801 computer family, and a Brother portable word processor that he "discovered" at the show.

In keeping with this month's declarative languages theme, Dick Pountain looks at two books on the subject—one on functional and the other on logic programming. He also introduces us to two new language systems. One, developed at Imperial College, is a new interpreter for the Hope language that runs on the IBM PC. The other is MacProlog, which has many improvements on the older micro-PROLOG and is an implementation for the 512K-byte Macintosh.

Our new man in the Kernel, Bruce Webster, continues with his inspection of new computer products. As was the case with his debut column—and will probably be true in the future—this month's column deals largely with Macintosh items. Particular attention is given to three development systems for the Mac.

And, on the West Coast, Phillip Robinson looks at Intel's iAPX 386, the 80C86, and Atron's AT Probe—a "hardware-assisted software debugger" for the 86 family.

Inquiry 253



COMPUTING AT CHAOS MANOR

The West Coast Computer Faire

Union Problems
PC-Write
Disk Maker I
Multiple Choice
EM-it
Color-400
SR-12
SuperKey
PC-MATLAB
Badges and Flowers
NaturalLink

BY JERRY POURNELLE

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

The floors aren't in, there are painters and carpenters everywhere, and we're working off folding banquet tables for fear that they'll drip paint on the furniture. The storeroom is filled with equipment and boxes full of incoming software. Chaos Manor lives up to its reputation. Withal, we're upstairs at last, and it's wonderful.

WEST COAST COMPUTER FAIRE

On the last weekend of March, I drove up to San Francisco for the Tenth West Coast Computer Faire. My taxes were due, and I was behind in deadlines; if I hadn't agreed to be a speaker, I probably wouldn't have gone this year.

This year the Faire was in the Moscone Center rather than Brooks Hall. Moscone is much larger than Brooks, so everything was on one floor. Even so, there was empty space. Of course, it wasn't as large as the 1983 Faire—the one that had Priority One and MicroPro out in the garbage area, and exhibits in the chair-storage room, otherwise known as the Black Hole of Calcutta—but it was about as big as last year. More important: the magic was still there. The Faire mixes hackers, publishers, vendors, dealers, and end users, and it is the only show where we all get together. I'm glad I went, and I liked it a lot—but I wonder if the Faire will survive.

The problem wasn't the new Prentice-Hall management. There were more than 100 first-rate speakers and panelists. More important, David Sudkin and his troops worked hard to give the smaller exhibitors—who are the real lifeblood of the Faire—a break. There were 60 minibooths, those postage-stamp-size affairs where many of the miracles we all take for granted now were introduced. When the smaller exhibitors had problems, David Sudkin paid attention. Alas, the problems were beyond his control.

San Francisco is a much unionized city. Moscone Center is a city-owned facility, and the city politicos have signed contracts giving control of Moscone to the shop stewards, who miss no opportunity to gouge exhibitors no matter what their size or wealth. For example, all exhibit space must be carpeted. They'll rent you carpet at their prices. If you try to save money by bringing your own, you then have to pay for having it spread out for you—even if you lay it down yourself. Exhibitors weren't allowed to assemble booths or carry equipment.

This sort of thing was bad enough at Brooks Hall, but Jim Warren was able to cajole and wheedle. There's a different crowd at Moscone Center, one unwilling to listen to reason. As an example: Barry Workman brought up a copy machine and unloaded it himself. Every few minutes some guy stuck his head into the Workman booth and pointed to the copy machine. "You'll pay for that," he muttered. Other exhibitors who attempted to do any of their own work had similar harassments.

It seems counterproductive to me. The small companies simply can't afford to pay hundreds of dollars for work they can do themselves. They don't make that much from the Faire in the first place. Many larger companies, who don't sell anything at the Faire but used to come to show the flag, have decided they've had enough and won't go to the Faire or indeed to any other show in San Francisco. Surely San Francisco didn't invest all that money in the Moscone Center just to drive conventions to San Jose?

CHOCOLATE BRIBERY ...

One reason I enjoy the Faire is the chance to meet old friends like Walt Bilofsky. It's a bit odd. Walt's Software Toolworks is actually located no more than a mile from Chaos Manor, but the only time we see each other is at a Faire 400 miles north.

As usual, Walt had a bewildering line of CP/M, Zenith, and IBM PCompatible software: chess players, text editors, C compilers, an operating-system enhancement

(continued)

called C/NIX that's said to give CP/M systems a UNIX-like capability, and too much other stuff to mention. He also sells The Original Chocolate Byte, which is a thick chunk of excellent chocolate shaped like a 5¼-inch floppy; it comes in a reusable plastic disk box and makes a pretty good gift, except that if you're a chocolate addict like me, it won't last long enough to be given away.

The Software Toolworks catalog is full of good stuff at reasonable prices—none of it copy-protected—with a sensible copyright. "Copying this software or document for other than original purchaser's use is prohibited." If you don't have Walt's catalog, do yourself a favor and get one.

More Old Friends

Bob Wallace was at the Faire. Bob pioneered the concept of *shareware* with his PC-Write text editor. It's a good editor, worth more than the 85 bucks he wants you to pay for it—especially now that he's added mail merge and some other features. Under the shareware concept, you don't have to pay $85, though; you get PC-Write from Quicksoft for 10 bucks, or you get a copy from a friend for free. If you like it, you send $75 to Quicksoft and become a registered user, which entitles you to a printed manual, telephone support, and update information. It also entitles you to a commission if you give a copy to anyone who subsequently sends in the registration fee.

The shareware concept seems to be working: Bob and his friends aren't getting rich, but they're paying the rent and making enough to keep improving PC-Write. I wish them well.

Another friend I seldom see except at the West Coast Computer Faire is Bruce Tonkin, who writes the most amazing programs in compiled BASIC. His MyWord! is a really neat text editor and word processor with features like list sorting and calculating that you won't find in some of the really expensive programs. He's constantly adding to MyWord!'s capabilities, and it will run on quite a few machines, including just about all the PCompatibles. He does other stuff, too, all at superlow prices.

Bruce shared exhibit space with Barry Workman, who bundles some of Tonkin's best programs into a set called The Software Essentials. In fact, Workman's booth did yeoman service: in addition to their own stuff (including WRITE, the CP/M text editor I'm using to write this), they had demonstrations of Disk Maker I from New Generation Systems, a system that will transform disks from just about any format to any other (we have one and we love it). Mycroft Laboratories, whose MITE communications programs have kept me in touch with the world these past several years, also gave demonstrations. While you're writing for catalogs, get Workman's.

Disk Maker I works so well that I seldom get a chance to review any other product. However, the chaps at Berkeley Software have added another dozen or so formats to what their XenoCopy software can handle, and while I haven't used it myself, people I trust swear by their stuff. If you have data-transformation problems—and who doesn't?—you might want to write for Berkeley's data sheets.

A Quick Run-Through

The problem with writing about the Faire is that there's too much to cover. I used to do a separate article about the Faire and still felt there wasn't enough room. That leaves me two choices: I can try to cover a few things well, or I can follow my instincts and say fewer words about more stuff. I've opted for the latter. Do understand the ground rules for show reports: I can describe what I've seen, but I make no guarantees. I think I can usually tell if I'm being fed a line, and I certainly won't favorably mention anything I have some reason to believe is flawed; but my opinions remain tentative about anything that hasn't been put through the wringer here at Chaos Manor. With that warning, we can get on with it.

One thing I have no trouble recom-

(continued)

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mending is Rachel Holmen's *Truly Portable* (POB 2916, Oakland, CA 94609), which is an excellent 16-page newsletter about lapboard computers. It comes out 10 times a year, and a subscription is $16. Anyone interested in lapboard machines—and especially anyone contemplating buying one—will find *Truly Portable* worth the investment; it has product information, reviews, programs, letters from users, and lots more.

I can also recommend Carl Landau's *Computer Language* magazine (131 Townsend St., San Francisco, CA 94107) for anyone interested in what's going on in the language world. This has become an important magazine for hackers, and anyone seriously thinking about professional work in computer programming—or who wants to know what hackers are reading—will find it valuable. I'm not sure precisely how it happened, but *Computer Language* was partly designed on my kitchen table; my son Alex is a friend of the founders. Neither of us has any special relationship (or financial interest) with the magazine; I just find it interesting to read.

An award for sheer persistence should go to Ken Snapp of Beta Tools Systems. He has been sending me his BASIC Development System for six months; I must have received a dozen copies. This time he handed me one in person.

The BASIC Development System is a set of tools to use when writing programs in BASIC for PCompatibles. (Due to the way IBM implemented BASICA, there are separate versions of the BASIC Development System for PCs and PCompatibles. Note also that you must have your own copy of BASICA or GW-BASIC.)

This looks like something I'll use; the manual seems clear enough, and the features—cross-referencing, trace, dynamic dumps of variable values, selective renumbering, and compression/expansion—certainly ought to make it easier to write BASIC programs. Indeed, I have a good bit of BASIC programming to do (I have to work on Mrs. Pournelle's reading program); alas, what with the reconstruction of Chaos Manor, I haven't written a line of BASIC (or any other kind of code) for months, which is why I've done no more with the BASIC Development System than look at the manual. I'd be astonished if it didn't work as claimed, though: why in the world would anyone so persistently work at getting me to try something that wasn't pretty well debugged? Anyway, I'll know soon enough: Mrs. Pournelle is increasingly impatient to have her program finished.

POOR MAN'S TOPVIEW

Jason Loveman, who left Digital Research to found a company called

(continued)

THE SIMPLE APPROACH IS THE SYMBOL APPROACH.

```
10 S=0
20 FOR I=1 TO 100
30 INPUT X
40 IF X = 0 GOTO 70
50 S=S+X
60 NEXT I
70 PRINT S/(I-1)
```

BASIC
A program to calculate averages...

```
   REAL X(100)
   READ*,N,(X(I),I=1,N)
   S=0
   DO 10 I=1,N
10 S=S+X(I)
   PRINT *,S/N
   END
```

FORTRAN
just shrunk from seven lines...

```
(+/X)÷ρX←⎕
```

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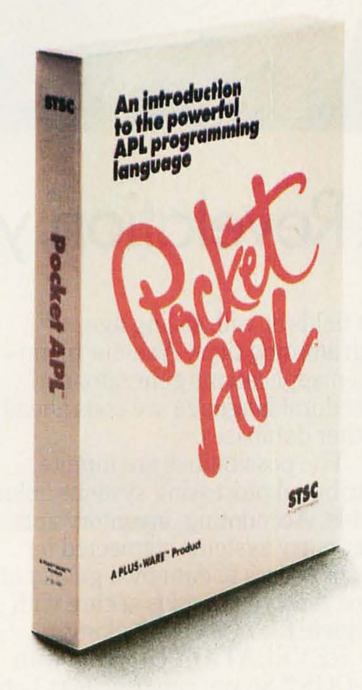
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Inquiry 311

Awesome Technology (yeah, I know), brought around a PC-DOS program called Multiple Choice, also billed as Poor Man's TopView. This program makes three computers out of your PC or PCompatible. That is, you run the program. It puts 4K bytes of code up in high memory. Now you enter Control 1, Control 2, or Control 3, and you're in job 1, 2, or 3. It works invisibly, and we've run it with the IBM PC with the Orchid PCturbo 186 board, as well as with the Zenith Z-150 and Z-160 PClones. It's compatible with SideKick. I've got it here at Chaos Manor (I'm running it now on the Z-160), and it works fine. For $64 you can have WordStar, DOS, and Lotus 1-2-3 running all at the same time (with SideKick in the background already yet). Who needs Symphony? Recommended.

YET ANOTHER EMACS

Another minibooth featured EM-it, an EMACS imitator. EMACS is the macro editor written at MIT by Richard M. Stallman (otherwise known as RMS). EMACS was one of the very first full-screen editors in existence. I recall several long-distance debates (I have an account on one of MIT's large computers) with RMS over the virtues of EMACS versus Electric Pencil, which was the editor I was using at the time. The debates were futile, of course: Pencil and WRITE (derived from Pencil) were *much* better editors for creative writing, but EMACS was far and away better for programming, and indeed it became a bit of a legend among hackers.

Stallman, who believes software ought to be available to everyone, put EMACS in the public domain instead of getting rich from it. The chaps at Sayansi have implemented it for PCompatibles and sell their version for $49.95, a reasonable price. Needless to say, it's not copy-protected. It's also not full EMACS. One of the main features of EMACS is its extensibility: you can add nearly any feature you might want from right inside the editor. EM-it can't do that, but it does

(continued)

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have some impressive macro capabilities. I saw it run on a PCompatible, and it looked very EMACS-like to me.

FORMIT from Emerald City Software is a text-formatting program that works something like WRITE does. That is: WordStar, and many other text editors, print on a "what you see is what you get" basis. This is fine for letters but not so hot for complex documents—and a decided nuisance for very simple things like manuscripts. WRITE has a number of "dot" commands (the command is given by starting a new line with a period, something you never do in ordinary English) that tell the program what I want done with the line. For example, .ce3 means center the next three lines, .pw65 means make the lines 65 characters wide (on average if we're doing right justification), etc.

FORMIT works the same way. It has a rich command structure and works with Epson dot-matrix printers. The authors claim they're continually adding other printers it will work with and that they're at work on "full, font-level support for all smart printers."

FORMIT is *freeware*; that is, you can have a copy free (it's available on bulletin boards, or by sending a formatted disk with return postage to the authors, or from anyone who has a copy), but you're expected to pay $15 if you use it. Fair warning: FORMIT is intended for users willing to pay attention and do a bit of experimenting. The manual (which is on disk—you print it out yourself) is complete enough, but the nature of the program requires you to do a bit of thinking. FORMIT requires an IBM PC or a generic MS-DOS machine with at least 128K bytes. Recommended for those who don't have a text formatter; it's sure easier to use this than to go through a document making changes.

Checks and Balances

My friend and colleague David Gerrold was at the Faire, but I didn't see much of him. He did hand me a copy of a program called Checks and Balances, which was written by a

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friend of his. As the name implies, it gives checkbook balances; but it does a lot more than that. Indeed, it seems to be a pretty fair accounting program. It has room for 64 categories of income or expense entries: things like "Income from books" or "Utilities." Each of these would then be a ledger page. Alas, I have more than 225 pages in my chart of accounts, so I'm not too likely to have a use for it; but someone with simpler requirements would probably like it. I guarantee this program is easier to set-up than my accounting program is.

REAL BARGAINS

A few readers have sent letters wondering why I mention Workman and Associates as often as I do. It's simple enough, and it has nothing to do with friendship. They put out real bargains. As an example: Disk One in the new PC version of the Software Anthology Series. This disk is *crammed* with routines to defeat copy protection, recover lost data, set up special batch files, and generally make life simpler for PC-DOS and MS-DOS users. Some of the software is freeware for which Workman has bought an unlimited-distribution license. Some is public-domain stuff gathered from bulletin boards and users groups. It would take a while to assemble this much software, and if you were doing it yourself, you'd still have to figure out what works and what doesn't. As with Workman's CP/M Software Anthology disks, there are several programs each worth more than he charges for the disk; I know, because I use the stuff all the time.

WONDERFUL WORLD OF COLOR

There was a time when the West Coast Computer Faire was the place to announce new hardware. I recall startling new stuff introduced at the Faire by CompuPro (now Viasyn), Sage (now Stride), Osborne (now recovering from Chapter 11), Fortune 32 (now—oh, well), and others. There wasn't anything like that this year (or if so I missed it). There was, however,

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a lot of stuff that was new to me.

The most impressive was a combination: the Sigma Designs Color-400 PC graphics board and the SR-12 color monitor by Princeton Graphics. The SR-12 has 640- by 400-pixel resolution that's steady as a rock; and the Color-400 board drops invisibly into the PC to give monochrome quality to color software. I stood there and stared: text is as crisp and steady as if painted on the screen, good enough to write with hour after hour.

I've arranged to get both the SR-12 and the Color-400. The SR-12 gets hooked up to a video switch so we can compare the Color-400 to our new CompuPro PC Video board that goes in our big CompuPro S-100 80286/Z80 system. Princeton also has the MAX-12, a crisp amber-screen monitor that knows whether it's being fed input from a PC monochrome or PC color board and adjusts accordingly, and other impressive monitors I hadn't seen before. I'm told by people I respect a lot that Princeton Graphics has long had the reputation for being among the very best in its field, and they're astonished I didn't know that; which just goes to show . . . or something. I can plead that because I wear bifocals I tend to prefer 15-inch monitors, but in fact it's plain that neither I nor anyone else can keep up with this wonderful kaleidoscope we call the micro revolution.

Borland's SuperKey

The saga of Philippe Kahn's Borland International is a graphic illustration of the plus side of the history of the micro revolution. Two years ago Borland wasn't at the Faire at all. Last year they hurriedly put together an exhibit. This year they had as large a presence as anyone except IBM and AT&T.

Borland introduced SuperKey, their new keyboard macro package that does just about everything my former favorite, Magic Keyboard, did, plus a bit more. I'll miss Magic Keyboard's toggle to PC graphics characters, but SuperKey is more versatile—and of course it's guaranteed to work with the indispensable SideKick. I don't run many PC programs that won't work with SideKick.

Borland now has Turbo Pascal 3.0, a distinct improvement on the already impressive version 2. I particularly like Borland's new licensing agreement: treat the software like a book, which is to say, make all the copies you want but don't have more than one copy in use at any given time. This seems quite fair to me.

The Turbo manual isn't quite good enough to learn Pascal with no other aid, but it's close. There are lots of examples, and the whole thing is written in good English. Turbo Pascal has got to be the best value in languages on the market today—and Borland International, by delivering excellent products at reasonable costs, is leading the software industry where it has to go.

I've said this before. In my judgment, the $500 program is a dinosaur. One reason for this is Borland: Turbo Pascal is more than just a good program at a low cost. It's also a low-cost, well-conceived programming language making it possible for *lots* of people to produce good programs.

LaPlace

One example: LaPlace, by P. L. Hagelstein, is a program written in Turbo Pascal. It's hardly a slick item: it took me five minutes of hard work to find the name and address of the publisher! It's nowhere given on the instruction sheets and given in only one place in the program display.

LaPlace is a program for calculating and displaying potential fields. To quote its manual: "LaPlace solves the Laplace, Poisson, and inhomogeneous Poisson equations in 2-D through numerical finite element methods. The matrix equations resulting from the finite element analysis are solved using the fast incomplete Cholesky conjugate gradient technique, which allows problems with 1000 nodes to be solved in less than 10 minutes."

That's specialized stuff. I doubt any commercial software house would develop something like that—but it's the

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kind of thing that if you need it, you need it bad. I intend to use LaPlace to play about with gravitational fields made complicated by the presence of small black holes. I expect a more conventional use would be in fluid dynamics or electrostatics.

Obviously I'm not competent to say whether or not LaPlace gives the right answers. The diagrams and displays *look* right, and there's a very extensive manual: the computer parts are in baby talk. The rest is written for people who understand inhomogeneous Poisson equations.

MATRICES

Another specialized program, PC-MATLAB from The Math Works, does just about anything you might want done with matrices: addition, multiplication, inversion, eigenvalues, and the like, and by making use of the 8087 coprocessor available in most PCompatibles, does it *fast*. I'm going to have to come up with a different "benchmark of sorts"; the one I devised a couple of years ago is performed by PC-MATLAB so fast that I can't time it.

Matrix operations are important to anyone trying to do multiple regression analysis, stationary time series, factor analysis, operations research, and just about any other kind of statistical prediction. Over the past few years a program called MATLAB has become a sort of standard for doing matrix operations on mainframe computers. Now it's available for a PC (but only one with an 8087 math chip).

PC-MATLAB comes with a rather complete manual. It's plenty easy to install and use, provided that you understand something about matrix operations to begin with. Matrices are input rather simply. A = [1 2 3; 4.1 5.6 6.7; 7 8 9] enters the 3 by 3 matrix

```
1    2    3
4.1  5.6  6.7
7    8    9
```

and, mercifully, the entries are put into a file that can be edited with a normal full-screen text editor, so that if you have a data-entry mistake, you don't have to input the whole matrix again.

I've found matrix math both interesting and useful since my days at the University of Washington, when Paul Horst taught us to apply matrix algebra to such problems as grade prediction. Matrices are very powerful tools; the only problem is the horrendous amount of arithmetical calculations required. One of the nice things about small computers is that they make it simple. Anyone wanting to understand the world would be better off for mucking about with this program; and of course every math teacher, at any level, ought to have it.

Alas, there are two problems. First, PC-MATLAB is copy-protected. It's not

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an obnoxious form of protection, and I suspect that fully half the people who'd be interested in the program know enough about small computers to remove the copy-protection scheme in five minutes. Still, it's there.

More seriously, they want $695 for it. That's a lot of money. PC-MATLAB is probably worth that to the relatively small number of people who want to use it professionally; but at that price it's not going to put matrix tools in the hands of social scientists and others who need to know about these things.

SOFTWARE TOOLS

All—well, nearly all—programmers keep hoping for the magic "software bus": a set of programs and libraries that lets you patch together a bunch of concepts to get the job done without extensive writing, editing, and debugging. It's one of the main reasons for the popularity of UNIX among hackers.

Back in the early days of micros there weren't many good books on computing, but one stood out so far above the crowd that there almost wasn't a second. That was Brian W. Kernighan and P. J. Plauger's *Software Tools* (still in print and very much worth reading). This was a book about programming philosophy; but it gave many examples as part of the discussion. These software tools became legendary. Walt Bilofsky named his software house Software Toolworks in their honor. My mad friend MacLean daily lamented that we didn't have them, and all of us wanted them. Alas, they were written for big machines and in a language called RATFOR. RATFOR = RATional FORTRAN; it was a preprocessor that allowed FORTRAN programmers a chance at writing structured code. A public-domain Z80 RATFOR precompiler was obtainable, but FORTRAN for our early 8-bit machines left a lot to be desired.

Then, at a West Coast Faire, I found an outfit called Unicorn Systems that published the software tools for small microcomputers. Eagerly I brought them home, only to find that most of them were already pretty outdated, and they didn't work too well under CP/M anyway; too slow. Unicorn also wanted too much money, although given what you got—15 disks of source code—it's hard to see what they could have done to keep the price much lower. Everything worked just fine, but the availability of the software tools for micros had far less impact than I'd have thought.

Unicorn has since become Carousel Tools. They've put the Legendary Software Tools into MS-DOS 2.0, which is *much* better suited to their structure than CP/M ever was. The tools use UNIX-like pipes, which is to say that the output of one program can become the input for another; it's

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possible to do an enormous job employing half a dozen different programs applied one after the other with a single command. MS-DOS 2.0 knows how to do that with the tools.

Anyone trying to learn how to hack should become familiar with the Kernighan and Plauger book and would likely benefit from having the Legendary Software Tools to play with. I haven't used the new set, but knowing the people at Carousel, I'd be astonished if there were significant undocumented bugs.

BEYOND COMPARE

Larry Niven and I write books together. We both use computers to write. Generally we don't work on the same part of a book at the same time unless we're working together. Sometimes it happens, though, in which case we have two versions of the same text—and neither is "latest."

When that happens we haul out COMPEN, a file comparator that looks at CP/M text files and displays their differences. COMPEN (from Compare Pencil files, showing just how venerable that program is) is available in the Workman CP/M Software Anthology Series.

Beyond Compare from General Transformation Company is a program for the IBM PC that does a great deal more than COMPEN does for CP/M files. If you use a PC or 100 percent PCompatible and have 256K bytes or more of RAM, I recommend Beyond Compare; it's worth the cost.

FOR THE RECORD

Epson America had a big display extolling the virtues of Valdocs 2.0, a program announced last fall and available Real Soon Now, for sure. I understand that Rising Star Industries, the outfit that's supposed to produce Valdocs 2.0, recently laid off a number of its programmers. As I heard the rumor, the people laid off were those who had finished their part of the project. This gives interesting incentives to those who haven't.

The last time I mentioned Rising Star's problems getting Valdocs 2.0 completed, Roger Amidon, chief programmer for Rising Star, called me. He wanted to know if I'd do a fair evaluation of Valdocs 2.0 when I got it. I promised I would, but I'm not holding my breath until I have to pay that debt. I've also got a self-promotional newsletter from Rising Star promising Valdraw and Valpaint, which require Valdocs 2.0, "Ready for shipment May 15, 1985." I wonder if I can get odds on that bet?

I'd have lost. We received Valdocs 2.0 in mid-May. It seems to work; more next time.

AT&T BADGE WATCH

AT&T's people had a big booth at the Faire. They had one at the Winter

COMDEX in Anaheim, too. You'll recall a year ago in Las Vegas I could tell the rank of the AT&T employee by the badge: plastic or paper for low ranks, then moving up through short silver, wide silver, narrow gold, to the senior officer present who had a wide gold badge. Apparently someone read my column; at Winter COMDEX *all* of the AT&T people had narrow gold badges. I fear I made a couple of untoward remarks that may have been overheard.

At the Faire they all had identical white plastic badges. However, they also wore carnations: white for PR people, colored for technical personnel. They'd solved The Great Badge Problem!

On the other hand, there was no one there who'd admit ever having heard of me or BYTE, and I didn't care to explain myself, so I didn't see anything. I suspect that if they'd spend more time having their media specialists learn something about computer publications, and less worrying about the size and color of their badges, they'd sell more computers; but perhaps they know something I don't.

HyperDrive and Corvus

Just before the Faire my Macintosh returned from General Computer with the HyperDrive installed. HyperDrive is an internal hard disk plus conversion to the 512K-byte Fat Mac. It took General about 12 days (including shipment to and from the east coast) to do mine. I love it. It works splendidly, it seems quite rugged, and it's *fast*. I'll have a lot more to say about HyperDrive in upcoming issues.

My son Alex works with Barry Workman and managed to wheedle me into lending him the HyperDrive Mac to use at the Faire as the demonstration machine for Workman's Macintosh software. They took it up in a truck; when it returned, it made a slight rattling noise.

I had visions of warped bearings in the hard disk. The noise was intolerable. With trepidation I got out the #5 Torx driver and opened up the Mac—something I don't recommend that readers do, since there's about 28,000 volts stored in condensers, and the insides of a Mac can be dangerous for *months*. Anyway, once inside, the problem became obvious. As part of the HyperDrive conversion, General puts in a small fan at the top of the Mac. The fan is put in with double-sided sticky tape, and it had slipped just enough that the fan blade hit the tape. A tiny nudge—which could have been done from outside, had I but known—took care of the problem.

As I said, the HyperDrive seems

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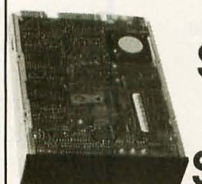
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rugged enough. It's quiet again, and it sure is faster than a normal Mac.

David Ramsey of Corvus Systems heard that Alex was bringing my machine up and arranged to bring one of the new Corvus hard-disk drives for the Macintosh over to the Workman booth. They plugged it in. Worked fine. Workman now had the most complete Macintosh in the show: two floppy-disk drives, 512K bytes of memory, and *two* hard-disk drives. Needless to say, in that configuration the Macintosh is *speedy*.

I'm told that my second Macintosh just arrived. It's being converted to a MegaMac (full megabyte of memory), after which it gets the Corvus hard disk. I'll then compare MegaMac plus Corvus with the HyperDrive. Report Real Soon Now.

GAMES AND SYNTAX

One chap who came looking for me at the Workman booth was Bob Woodhead, coauthor of the popular Wizardry I game. He had the latest version for the Macintosh, and it didn't take long to get me playing it. If you have a 512K-byte Mac, the whole game (more or less) fits into and fills memory; this speeds things up considerably. You can play Wizardry I on the 128K-byte Mac, but be prepared to wait for disk accesses.

Wizardry I is complex. At bottom it's supposed to be like the dungeonesque game TSR bombastically threatens to sue you for mentioning, in that you take a party of adventurers into a maze-like dungeon, where you encounter all sorts of monsters. You can fight or run, and if you fight, your magic-using characters can cast spells.

It's all very interesting, and when I got Wizardry I home, I spent too much time playing about with it. I'm not sure what the game's fascination is. I *hate* mapping mazes, and there's more of that than anything else with Wizardry I.

Mostly, though, it got me to thinking about games and programs.

Adventure/exploration games come in a lot of flavors, but tonight I'm interested in two basic classifications: menu-driven, like Wizardry I, and command-driven, like the original Adventure game of Crowther and Woods.

Menu games can be fascinating. Wizardry I has lots of graphics and considerable ingenuity. At bottom, though, what you can do is known in advance to both you and the computer. You give a command, and the machine does it. The program needs no ingenuity, since if you give a command that's not on the menu, neither you nor the machine has a problem. In Wizardry I the machine either beeps or responds with "What?" In both cases, you simply enter a new command.

(continued)

SNEAK PREVIEW
of a powerful
NEW SOFTWARE METAPHOR
WANTED: People with Imagination, an IBM PC, and $59.95.

by Paul Heckel

President, QuickView Systems and author, *Elements of Friendly Software Design*

Rarely does a software product introduce a new conceptual metaphor. VisiCalc introduced the electronic spreadsheet; Thinktank, the electronic outliner; and now *Zoomracks*, the electronic rack. Let me tell you what electronic racks are, why I think they are important, and how you can get to try them risk-free at a savings now and maybe help shape their final form to your liking.

New Metaphor:

Originally designed to keep track of lists, names and addresses, appointments, notes, and other information on portable computers, electronic racks provide a simple, consistent and rich organizational metaphor for data base, text, and other applications.

Zoomracks starts with something familiar: racks—like those filled with time cards next to time clocks in factories. You can see the first line of each card, and take out a card to look at it in detail. You expect the cards in a rack to be in order, several racks to be next to each other; and to be able to move cards from one rack to another.

You might put names and addresses in one, appointments in a second, notes in a third, sales orders in a fourth, memos in a fifth, and archived appointments or notes (moved or copied from the second or third rack) in a sixth rack. To do something with Zoomracks, first ask yourself: "How could I do it with cards in racks?"

ZOOMRACKS SPECIFICATIONS:

- Copy and move fields, cards, and text into different fields, cards and racks.
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- Utilities to convert DBASE II files.
- Macros.
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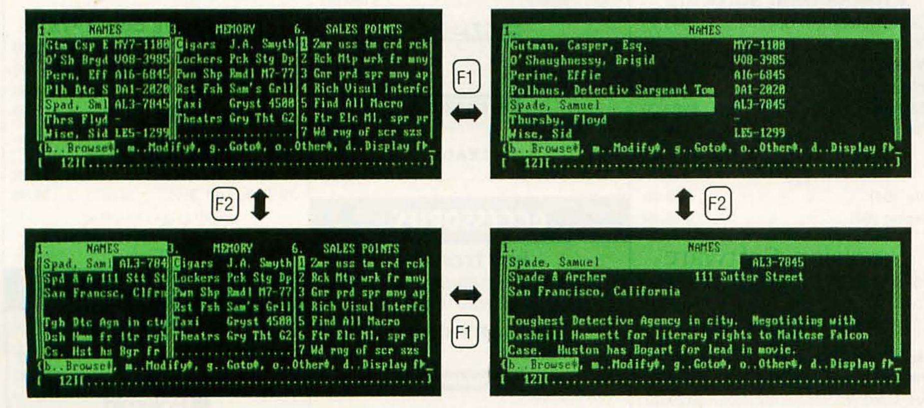
Windows illuminate like a flashlight in a dark room

Racks are displayed with Smart Zooms. While windows sacrifice the big picture to let you see the detail, Smart Zooms squeeze out the detail to always show you a recognizable big picture—whether a long shot of several racks, a closeup of one rack, or an extreme closeup of a single card.

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The Wide key (function f1) toggles between displaying the working racks (left two screens) and the current rack full (right two screens). Smart Zooms compress out detail to keep the big picture.



The Yank key (function f2) toggles between displaying the first lines of cards in racks (top two screens), and the current card (bottom two screens). In these pictures Zoomracks is using a 10 by 60 screen.

Before developing Zoomracks, Paul Heckel studied what made VisiCalc and other software powerful, useful, easy to use, and successful. He crystallized his thoughts in a book. This is what people are saying about this book, *The Elements of Friendly Software Design:*

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Command-driven adventure games are much different. You don't know what you'll be allowed to do. The machine knows what you're permitted, but it doesn't know precisely how you'll give the command. Sophisticated games, like the excellent Infocom series, have highly complex program structures, including a *command parser* that looks at what you ordered and tries to make sense of it. Often it succeeds.

In command-driven games you must experiment. Sometimes you have to do a lot. Badly designed games of this sort are terribly frustrating: you sit there and try what look like perfectly reasonable actions, only to be given some stupid generic message like, "I don't understand that." In the ideal case, though, the game designer will have thought of everything you might want to try and has built in some kind of response appropriate to what you tried. "Dig." "I see no shovel here."

Even the well-designed games can be frustrating, since you're trying to solve a puzzle, and you can't be *sure* that the designer even considered the ingenious idea you've just come up with for getting past the forest of skeletons or whatever blocks your path. Moreover, because you have to figure out what you're allowed to do, it takes longer to learn how to play command-driven games.

By contrast, you can play menu games almost instantly. All you have to do is read through the rule book or examine the help file or whatever. Thus I find that menu-driven games catch my attention quicker than the command type.

However, I also find that I tire of them sooner. In Wizardry I, for example, once I learned the menu of commands, it was easy to move about in the dungeon. (Not too easy: I managed to lose no fewer than 11 first-rate characters before I caught on to what I was doing wrong and tried a new approach.) At first that was fun. Then, as I learned the shape of the maze and the nature of the puzzles, I longed for the ability to do multiple moves. In-

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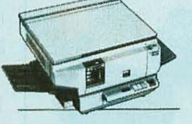
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NaturalLink converts a command-driven program into a menu-driven program.

focom's designers have built in the capability for inputting whole strings of commands: Go east. Take sword. Kill troll with sword. Attack. Run away. Go south. The whole command string is considered one move at a time; if, for example, you killed the troll with the first stroke, the program would ignore the other commands to attack and ask for new instructions.

I wish I could do that in Wizardry I. For that matter, I wish I could use the Adventure trick of dropping objects to mark various passages and rooms: most of the Wizardry I dungeon is a maze of twisty little passages, all alike, and mapping them is tedious at best.

The conclusion from this is obvious: when you're first starting, it's best to have a menu; but after you've been at it for a while, you'll prefer commands.

Games may be thought frivolous, but the fact is that a good game command parser, like Infocom's, is a fairly hefty achievement, with profound implications for the whole field of artificial intelligence. After all, what we're really seeking is a way to let us control computers without having to use special commands. In the ideal case, we'd simply tell the machine what we wanted and watch it do it. Some of the Infocom games get pretty close to that ideal—but of course they're working in a restricted universe.

A computer program *is* a restricted universe.

TI'S NATURAL LANGUAGE

Something of the above seems to be the philosophy of Texas Instruments' new natural-language front ends. You can get a natural-language shell for DOS, Lotus 1-2-3, WordStar, Word Plus, the excellent BPS Business Graphics, EasyWriter, PeachText 5000, Knowledgeman, SuperCalc, MultiMate, and probably more that I didn't hear about. In addition, there's a sort of generic NaturalLink toolkit that can be used to generate NaturalLink shells for other command-driven programs.

NaturalLink in essence converts a command-driven program into a menu-driven program. With NaturalLink you begin to build "sentences" whose grammar and syntax are set by the application program the shell is built around. As you add words to the sentence, your choices become more restricted. Using WordStar as an example, begin with "I want to"; this is appropriate to any legal command in the program. Now add "edit," and the legal choices become only two: a document and a data (or nondocument) file.

As soon as your choices are narrowed down to one and only one, the NaturalLink program fills it in for you. It still doesn't execute the command. You get a chance to change things first.

The NaturalLink programs were delivered to me by Tom Siep of TI's corporate Human Factors facility (and I sure wish some of the other hardware outfits would start a human-factors center). TI's human-factors people classify users as beginners, experts, and occasional. The NaturalLink programs are designed for the first and last of those categories. Experts don't need them.

The NaturalLink shells have quick ways to get outside them and into the regular program the shell surrounds: into regular WordStar, or SuperCalc, or whatever. When you do that, the NaturalLink shell vanishes. It can be brought back easily.

Tom Siep was accompanied by Peggy Hart of TI's Austin research facility. They were visiting in Southern California ostensibly for the Winter COMDEX in Anaheim; that show was so small that I drove down for only one day and saw little to keep me there any longer. After COMDEX,

(continued)

they came up to Chaos Manor.

It's always interesting to see people here for the first time. I think no one really believes that my descriptions are accurate until they get here. Anyway, Tom and Peggy brought a box full of software, including the NaturalLink shells, and a TI Portable. The Portable is a luggable version of the TI Professional. Big Tex, our TI Professional, is *full* of boards, including speech synthesis. The Portable is comfortably less filled up, although, give it time . . .

The Portable has color. The TI Professional is one of the few machines with color good enough to do word processing on; the Portable lives up to that reputation. It also has a jack on the back so that you can pipe out the video display and put it on a large monitor.

Peggy Hart is involved in the design of the NaturalLink software. She isn't

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CHAOS MANOR

a computer-science type—which helps. Her husband is a professor of rhetoric at the University of Texas at Austin, which probably helps too.

TI is hoping that the NaturalLink systems will be a key factor in selling the notion that people, especially businesses, ought to use TI PClones. They just may succeed. I find the NaturalLink shells just the thing for programs I use only every now and then.

There's only one problem, which I brought up with TI executives during my trip to Austin. TI intended to license use of the NaturalLink tools to

(continued)

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Savvy seems to be the most interesting of the database systems that I've looked at so far.

software houses. They'd charge stiff up-front fees and even stiffer royalties.

"Who can afford to use them?" I asked.

They stammered a bit.

"Didn't you learn from the TI-99 disaster?" I asked. "Freezing out small developers is a sure way to doom."

"We know that. We're encouraging small developers."

"By charging anyone who wants to experiment with NaturalLink $1500 just to try it?"

"Well—that was expensive stuff to develop. How can we recover our costs? Because if we can't, then we've not got a lot of incentive to continue. Corporate will shut down the research effort."

I thought about that for a while and came up with what I think is an ingenious idea. "Look, you don't want 20 companies to pay you $5000 for NaturalLink. That hundred grand would be nice, but it's not a patch on what it cost to develop the program."

No one wanted to touch that one.

"What you really want is five bucks each from half a million copies."

"Sure—"

"But since no one can pick which software developer will come up with something that sells a million copies, what you need is to get the NaturalLink toolkit into the hands of as many developers as possible," I continued. "So. Give it away. If you have to charge anything at all, set the charge at your production cost. Don't charge royalties on products developed, either. Not at first. What you have them do is sign an agreement that they'll pay royalties on all the copies they sell after the first hundred are sold. That way you'll collect from the successful, and you won't discourage start-ups from using NaturalLink."

The TI people thought about that one. Last I heard they were going to try to get the corporation to adopt the policy.

I hope they do. NaturalLink is a, er, natural for occasional users like me. I can start work using the NaturalLink shell and switch over to command structure when I've refreshed my memory about the program.

More on NaturalLink and the TI Portable (well, Luggable) another time. I'm impressed with both.

WINDING DOWN

I'm running out of space, and there's still more to cover. There's a new version of Savvy, the odd database language that not only uses natural-language concepts but lets you spell the commands wrong. I find Savvy about the easiest-to-use PC database of them all. However, I have a letter from a reader who doesn't like the fact that Savvy isn't just a database but a whole database programming language that you have to learn to get its real benefits. It's all true; to me, having a database language is a feature, not a bug.

Savvy bills itself as "The Artificial Intelligence Database" and pretty well lives up to the reputation. It's not copy-protected. The license agreement is silly but not as stupid as most. There's a nice tutorial, and the manual has examples. Before he left us to go back to graduate school, Peter Flynn (who *cannot* spell) studied a number of the databases here at Chaos Manor and decided that Savvy was the one he wanted to implement on PCs and compatibles. I've a bit less experience with Savvy's rivals, but I'm coming to the same conclusion: Savvy seems complete enough, is easy to get started with, and seems the most *interesting* of the database systems I've looked at so far.

There's also MaxThink. This is an "idea processor" that purports to solve most problems writers face. There's even a section on overcoming writer's block. The authors of MaxThink claim it's much more useful than ThinkTank, which was the first of the idea-processor programs (or at least the first I was ever aware of). I find ThinkTank indispensable. I *think* I'm going to like MaxThink. Alas, it has

(continued)

many features, and the documents are formidably thick (and come in an awkward—for me—three-panel looseleaf notebook). When I read random passages, I find intriguing thoughts and concepts, but I've so far been unable to get involved in the tutorial. It's probably a combination of sloth and the fact that I'm used to ThinkTank. Unlike ThinkTank, MaxThink is not copy-protected. It seems to have advanced text-entry/editing features. There's much to like about it. Real Soon Now . . .

The game of the month has to be Wizardry I for the Macintosh; I've sure invested enough time in it. The boys have divided their time between Infocom's Hitchhiker's Guide to the Galaxy and Cygnus's Star Fleet I. I guarantee you won't enjoy Hitchhiker if you haven't read the book. For that matter, I wouldn't buy the game without the clues; even if you've memorized the book, those puzzles are *hard*.

There are three books of the month. *Modula-2, A Software Development Approach* by Gary Ford and Richard Wiener (Wiley, 1985) is an excellent discussion of why you want to write programs in Modula-2 and a good intermediate text on the language. Beginners will find it tough slogging but well worth the effort it takes. *Surely You're Joking, Mr. Feynman* by Richard Feynman (Norton, 1985) is a series of autobiographical anecdotes by the Caltech Nobel laureate who also is known as a wonderful teacher, and it has to be the most interesting book I've read in at least a year, just as *The Pentagon and the Art of War* by Edward Luttwak (Simon and Schuster, 1984) is the most important book I've read in some time.

Meanwhile, Tony Pietsch has Concurrent DOS and my CompuPro PC Video board ready to install in our big CompuPro S-100 80286/Z80 system. We've held off until we can get the machine upstairs; I've found that computers don't like to be moved, and I want to see it working "as was" in its new location before opening it up. We also have a pile of machines that have come in during construction and thus haven't even been uncrated. There's an HP with a ton of software; an Eagle Turbo PC; AT&T's 3B2 UNIX V box; the Stride 400; and the thoroughly updated Lilith. My new quarters have been designed to let me set up a mess of machines and work on them, and I'm already running out of bench space. It's a great life if you don't weaken . . . ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

Inquiry 37



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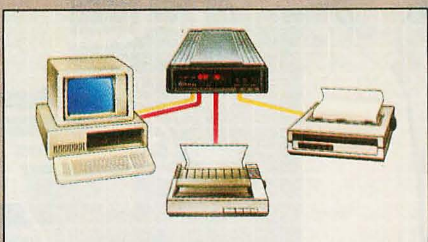
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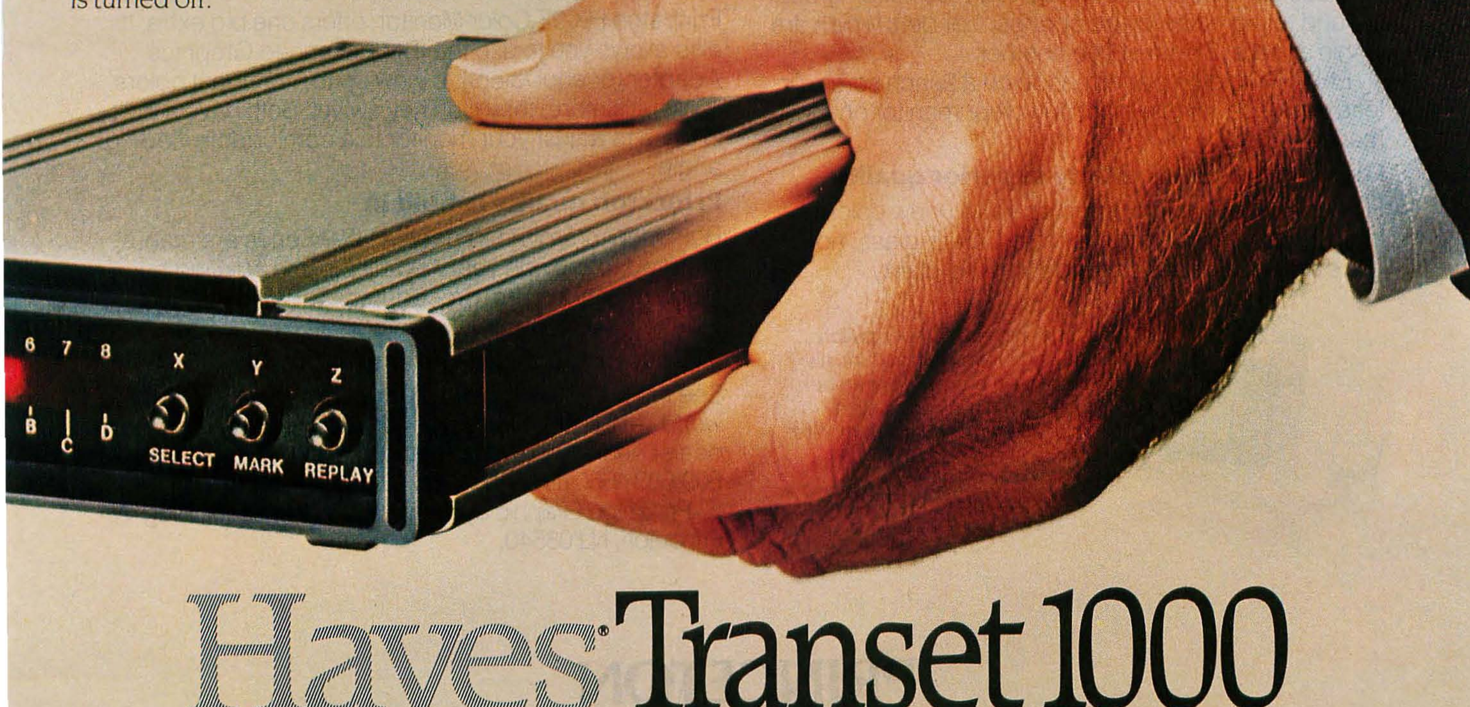
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BY WILLIAM M. RAIKE

As I'm writing this it's cherry blossom time in Tokyo; spring has finally sprung, and just about everyone is trying to arrange a little free time for *o-hanami* (flower viewing), walking or picnicking under the canopies of blossoms often found near local temples or shrines, as well as in the major parks. My favorite spot is Todoroki Fudoson, on the southwest outskirts of Tokyo; I was able to enjoy it for an afternoon just after the close of the first-ever COMDEX in Japan.

The COMDEX show was held at a strange time of year, only two months before the annual Microcomputer Show. It was also heavily oriented toward products for export, rather than for the Japanese market. The show attracted only about 40,000 people (including lots of non-Japanese) over three days, in a city of about 12 million. I think many companies were waiting for the Microcomputer Show to introduce their new goodies.

However, there were some interesting products on display. The long-rumored Fujitsu lap-size portable made its appearance, along with the NEC Starlet, the PC-8401A, which I previewed in January in this column. Ampere Corporation's APL-based lap-size machine (see What's New, October 1984 BYTE, page 42), now christened the WS-1, was finally on display, despite being some months behind schedule. Brother Industries showed its new portable word processor/typewriter and the companion floppy-disk unit. And laser printers were there in force, some of them downright cheap.

BADGE NEWS

Usually, the procedure for registering and entering a computer show here is simple and brief: You fill out a card, pay your money, get a badge, and go in. Not so for this show. After filling out a full-page questionnaire (with no desks on which to write) and standing in line for 30 minutes, I handed in my form to someone who entered the information into a computer terminal while I waited. Then an on-line badge-making machine coughed up my plastic badge (with my name misspelled).

The theory was that if you wanted an exhibitor to mail you additional information, the exhibitor would run the plastic badge through a credit-card imprinter, and that information would later be sent to the address already stored in the computer. At other computer shows, the usual procedure is simply to drop one of your business cards in a box at the exhibitor's booth; the exhibitor can mail off the additional information later and doesn't have to do anything about it in the midst of a crowded booth. In this case the badges were too flimsy, so the imprinters chewed them up; naturally, the exhibitors hated the whole process because it was such a hassle. Some sensible people just ignored the badges altogether and collected business cards. This is a perfect example of an ill-thought-out computer application that never should have seen the light of day. And I still haven't received any of the literature I requested.

ANONYMOUS FUJITSU LAP-SIZE PORTABLE

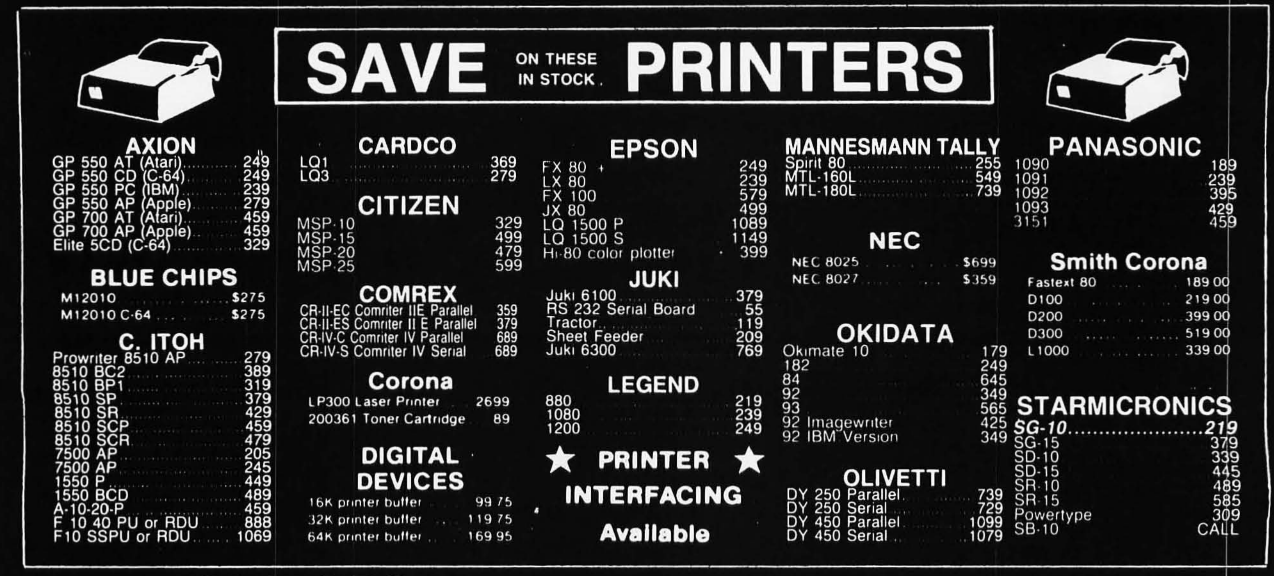
I may end up being the last one on my block to buy a lap-size portable computer. So far, I just haven't seen anything irresistible. Even so, I've been looking forward for months to the long-rumored Fujitsu portable, and I finally got a look at one at COMDEX. It's still so new that it doesn't have a model name or number; it was scheduled to be available in Japan in July of this year, with a target price equivalent to about $1350.

The Fujitsu portable is based on the MBL8086L microprocessor, a CMOS (complementary metal-oxide semiconductor) version of the 8086. Standard RAM (random-access read/write memory) is 128K bytes. You can expand the memory up to 448K bytes, and you can configure part of

(continued)

William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer. He can be contacted c/o BYTE, POB 372, Hancock, NH 03449.

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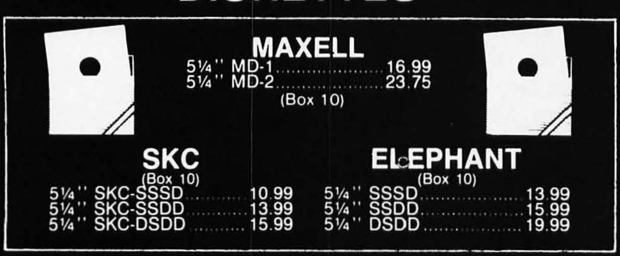
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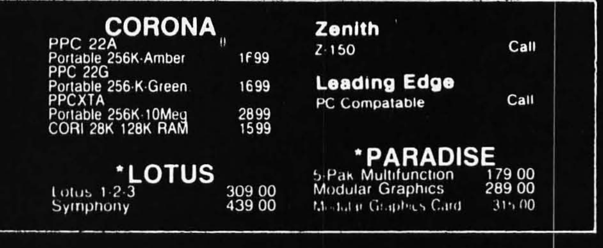
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RAM as a RAM disk. It acts like an extremely fast floppy-disk drive for fast file operations. You get 512K bytes of standard ROM (read-only memory): 256K bytes include the kanji ROM and a 19,000-word Japanese-language dictionary; the other 256K bytes are in a ROM cartridge that includes the operating system (Japanese-language CP/M-86) and languages or other software. At this point, Fujitsu offers cartridges that support Japanese-language extensions of BASIC and COBOL Level II (yes, COBOL); the company won't say what applications software will be available, but at the show I played with both WordStar and a Japanese word-processing program.

The computer includes an RS-232C serial interface, so some kind of telecommunications software support is certain to be present. Unfortunately, unlike some other lap-size machines, it has no built-in modem (Fujitsu does supply a separate acoustic coupler). This will be a serious disadvantage if Fujitsu decides to market the machine in the U.S., but it is not a problem here in Japan, which lags far behind the U.S. in the area of computer communications. People still use acoustic couplers over here, although the recent breakup of the Japanese telephone company, paralleling that of AT&T, will probably mean that affordable direct-connect modems will start appearing on the market here soon.

For external data storage, the Fujitsu includes a microcassette recorder, although an external 3½-inch microfloppy-disk drive will be available as an option. The disk interface is standard, along with the RS-232C interface, a bar-code-reader interface, and a standard parallel printer interface.

The Fujitsu has a very clear, easily readable liquid-crystal display (LCD); I had no trouble reading it even in the bright fluorescent glare of the exhibit hall. The 640- by 200-dot screen offers four display modes: an 80-character by 25-line mode for normal alphanumeric use; an 80-character by 20-line mode that allows on-screen underlining and better line separation; an 80- character by 11-line mode that gives double-height characters; and a 40- character by 11-line kanji display mode that displays kanji characters in a clear 16- by 15-dot font. The display adjusts to any convenient viewing angle and folds down to cover the keyboard when it's not in use.

Internal nickel-cadmium batteries supply the power, and an additional memory backup battery protects main memory for at least one month. An AC adapter is available, and Fujitsu says it will run off a car battery (called a *kaabatteri* by Fujitsu).

LASER PRINTERS

Laser printers have yet to make their impact in Japan, if you'll forgive a bad pun. Mostly, they're still expensive, bulky, desk-size contraptions. But the quality they offer is startling: You get magazine-quality printing at speeds of around 10 pages per minute. TEC (Tokyo Electric Company), whose daisy-wheel printers are marketed in the U.S. under the C. Itoh name, showed a tabletop laser printer at the show. The new BP-10 laser printer isn't available to consumers yet, but OEM (original equipment manufacturer) samples are going for only about $1200 apiece. The BP-10 is quiet, weighs only about 60 pounds, and comes with both 8-bit parallel and RS-232C interfaces. It prints 10 letter-size pages per minute at a dot den-

Laser printers have yet to make their impact in Japan, if you'll forgive a bad pun.

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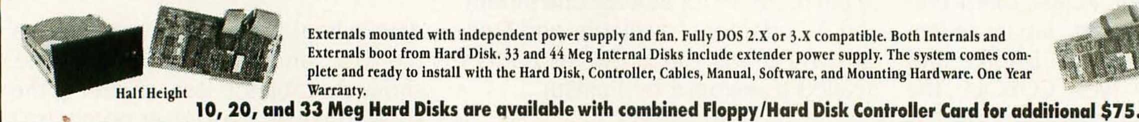
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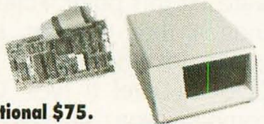
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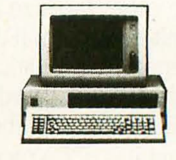
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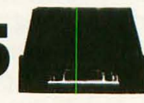
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sity of 300 dots per inch. I want one.

Another printer that impressed me was Fujitsu's latest dot-matrix printer, the DPL 24. It's a 24-pin printer with the best letter-quality printing I've seen from a dot-matrix printer. It is reasonably fast at 80 characters per second (cps), and it also has a 160-cps correspondence-quality mode and a 240-cps draft-quality mode. The DPL 24 has other nice features too, like selectable fonts using optional cartridges and the ability to download special fonts. It comes in two models: The Model D is Diablo 630 API-compatible, while the Model I was designed for use with the IBM Personal Computer (PC). Unfortunately, Fujitsu informed me that the DPL 24 was an export model and that there was no way I could buy one in Japan.

New from NEC

A recent addition to NEC's PC-9801 computer family is the PC-9801M3. The PC-9801 machines hold the dominant position in the microcomputer market in Japan, analogous to the IBM PC in the U.S. market. The latest model, the M3, is similar in most respects to its predecessor, the F3. The machine is based on the 8086-2 processor running at 8 MHz and comes with 256K bytes of standard RAM, expandable to 640K bytes. It has extensive Japanese-language capabilities, supported at the operating-system level by either CP/M-86 or MS-DOS or PC-UX, NEC's version of UNIX System III. (PC-UX is a $1200 option, though.) The machine is similar in most respects to the APC III sold in the U.S., but the main unit of the PC-9801M3 includes both a 1-megabyte 5¼-inch floppy-disk drive and a 20-megabyte hard-disk drive. (The PC-9801M2 I wrote about in the May BYTE Japan, page 355, has two 1-megabyte floppy disks.)

The price for all this is not unreasonable; the M3 costs about $3285, but the usual 20 percent discounts available in the Akihabara electronics district in Tokyo would bring that down to only about $2630.

Incidentally, NEC finally managed to put together a comparison sheet listing the differences between the U.S.'s APC III and Japan's PC-9801M2 and M3 computers. The major differences are that the Japanese computers have standard kanji-support ROM and a standard 1-megabyte floppy-disk interface, along with 256K bytes of RAM—versus 128K bytes in the APC III. The M3 also comes with a standard 20-megabyte hard disk. (The PC-9801M3 also contains an interface for 5¼-inch, 320K-byte floppy-disk drives, which can be connected externally.)

The basic character sets of the two countries' machines also differ slightly. The APC III is IBM-compatible but the PC-9801M2 and M3 use the JIS (Japan Industrial Standard) character set. The graphics video RAM configuration is also somewhat different. And there is an extra 8K bytes of text video RAM for kanji support in the Japanese machines. Finally, with the

A recent addition to NEC's PC-9801 computer family is the PC-9801M3.

Japanese machines you can select the processor speed: It can be either 8 or 5 MHz, while the APC III runs at a fixed 8-MHz rate.

Other than that, the differences involve the availability of optional boards and peripherals. For the Japanese machines, you can buy a cassette-tape interface, a music board, a 68000 central processor board and its companion RAM board, and a GPIB (general-purpose interface bus)

(continued)

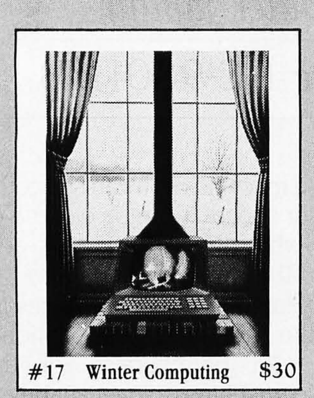
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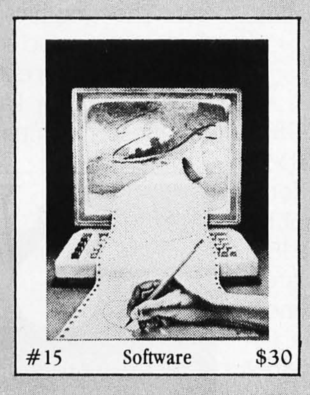
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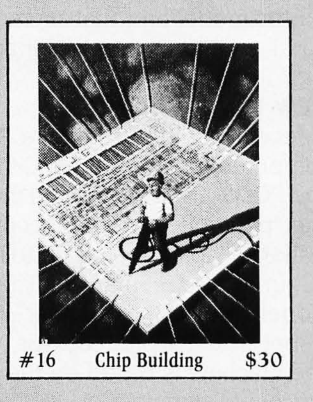
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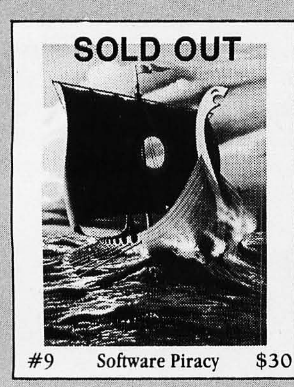
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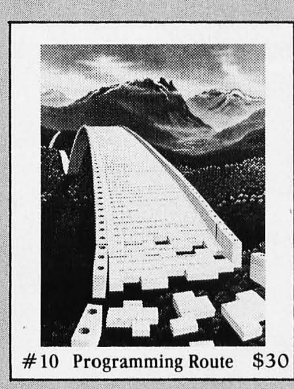
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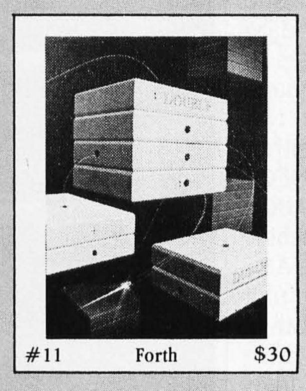
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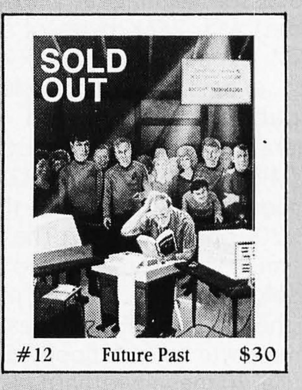
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board. Eight types of display units are available, along with a variety of kanji printers. Strangely, the printer interface is a conventional Centronics-compatible 8-bit parallel interface in both U.S. and Japanese machines, but the connector is different: The APC III uses a 36-pin connector, while the Japanese machines use a 14-pin connector on the back of the computer. The connectors on the printers themselves are standard 36-pin connectors. NEC is the only Japanese manufacturer I know that uses a different type of connector.

Brother Does It Again

Back in the October 1984 BYTE Japan I wrote about my Brother EP-44 portable electronic typewriter with its built-in RS-232C interface. Now Brother has come out with its new WP-600 portable word processor, and it's even better. The printing element is the same as in the EP-44; it's a 24-pin head that produces crisp near-letter-quality printing either on thermal paper or on ordinary paper using the built-in ribbon cartridge. I think the keyboard is much better, though—the key tops are sculptured, and the key travel and light touch make it easy to type quickly and accurately.

A 24-character LCD shows what you type; as you type, new characters appear on the right and the displayed characters are all shifted to the left, so that as a character is shifted off the left end, it is printed on the page. You can overwrite or correct any characters in the display. Alternatively, you can type directly into the memory and print out your document later. Common word-processing functions like underlining, insertion and deletion, centering, flush-right margins, global search and replace, and decimal tabbing are done with a control key, called a code key, which is just to the left of the space bar. Keys that perform the different control functions are clearly marked in blue on the key tops. The WP-600 also has a second shift key that allows each of the keys to be used for additional characters like European language symbols, the Greek alphabet, and special symbols.

The WP-600 has 14.3K bytes of user memory, organized into nine file areas. You can refer to files by name or number, and a file can be of any size up to the limits of available memory. Files can be combined, copied, or printed.

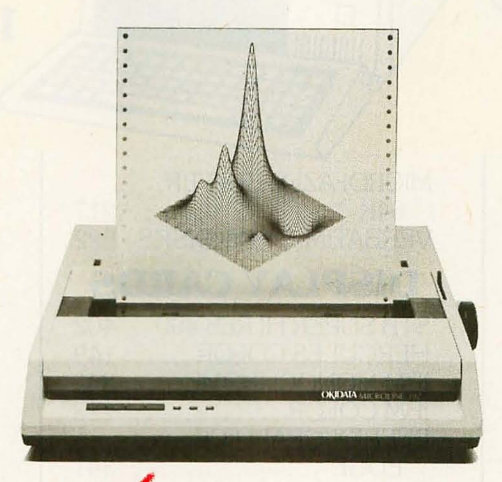
The built-in RS-232C interface can operate at rates from 75 to 1200 bits per second; you set the desired rate, parity, etc., using the display. When the front-panel switch is set to Terminal, the WP-600 becomes a full-duplex terminal or a serial printer, accessible through the RS-232C connector on the side of the unit. With less memory, my EP-44 works the same way; I use it as a second printer.

An outstanding feature of the WP-600 is that there's a portable battery-powered 3½-inch floppy-disk unit available for it. You can transfer files between memory and the disk by simple keyboard commands. The FB-100 disk unit is a little over 2 inches high, 5 inches wide, 6½ inches deep and weighs less than 2 pounds. Each 3½-inch floppy disk holds 100K bytes.

Here in Japan, the list price of the WP-600 is equivalent to only about $385, and the FB-100 floppy-disk drive sells for a surprisingly cheap $195 or so; they're likely to be available soon at discounted prices here in Tokyo. Brother assures me that both the WP-600 and the FB-100 will be available in the U.S. by the time you read this; I don't know the U.S. price for the WP-600, but the disk drive should have a U.S. list price of about $250.

Next Month

The September BYTE will be the 10th anniversary issue of the magazine. In my column I'll be telling you the history of Japanese microcomputers. ■



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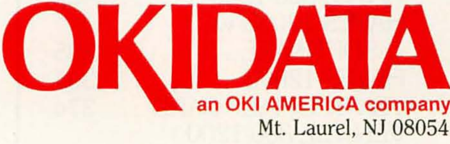
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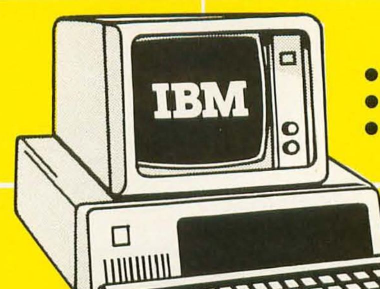
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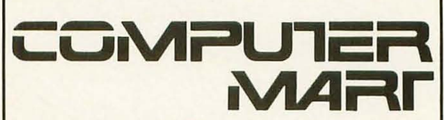
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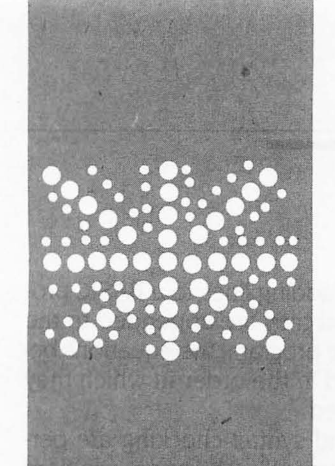


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B·Y·T·E U.K.

Declarative Update

Two new language systems and two new books

BY DICK POUNTAIN

Since the theme this month is declarative programming languages, I'm devoting my column to a miscellany of items that help personal computer users get in on the declarative act. To be more specific, I'll take a brief look at two new books on logic and functional programming and at two new language systems for the IBM Personal Computer (PC) and the Macintosh.

A GLIMMER OF HOPE

I have recently begun to learn the Hope language (see "A Hope Tutorial" by Roger Bailey, page 235) using an interpreter that runs on the IBM PC. This interpreter, developed at Imperial College, is available for downloading from BYTEnet Listings, (617) 861-9774.

The original Hope system runs at Edinburgh University as a compiler on a DEC-10 mainframe computer. A group at Imperial College subsequently produced an interpreter for a large subset of Hope for the VAX under VMS.

The computer department at Imperial College has been quicker off the mark than most in embracing the personal computer age. Research assistant Victor Wu has written a version of the Imperial College interpreter in Pascal for the IBM PC. Although Hope is still very much an experimental language, this interpreter is robust enough and easy enough to use that it can serve as an excellent learning tool; a degree in computer science is not required to get it running.

This new version of Hope runs under PC-DOS 2.0 and comes as two 8088 segments (i.e., 128K bytes), which leaves very little workspace to play with; an enhanced version will be able to use bigger memories.

The interpreter is booted by simply typing HOPE from the PC-DOS prompt, and it takes about 30 seconds to come up (mostly in-memory pointer juggling time rather than disk-access time). You are then presented with the Hope prompt >: and are ready to enter programs.

Using the Hope interpreter will be a familiar experience to anyone who has used a LISP interpreter on a personal computer; it works in a similar way.

Those readers who have only used BASIC interpreters will find it less familiar. Since Hope is a functional language, the activity of programming consists of declaring functions, whose definitions are then stored in memory; there can thus be a number of different "programs" in memory at the same time, whereas BASIC normally permits only one.

This raises a rather delicate point of semantics. In Hope, strictly speaking, a "program" is the application of a function to its actual arguments. As in LISP or FORTH, a series of definitions is entered, culminating in the definition of the function that does the job. To run a program, you type the name of this last-defined function with appropriate arguments. Nevertheless, to keep us on familiar territory, I shall talk about the definitions themselves as "programs" as they more or less correspond to the source code of a conventional program.

The Hope interpreter provides some facilities for inspecting and editing function definitions that have already been entered, though they could not be described as adding up to a full editor. I found that these are sufficient for entering small programs and learning your way around the system. For larger programs a separate editor makes sense.

I was pleased to find that the Notepad in Borland's SideKick program works extremely well in this role and gives you an editor that is available at a keypress from inside the interpreter (more on this later).

A Hope program consists of a declaration containing the name and type of a function, followed by a series of recursion equations that describe the value of the function for all possible patterns of its arguments. The required pattern matcher is built into the

(continued)

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, POB 372, Hancock, NH 03449.

interpreter. For example, a program to count the number of elements in a list looks like this:

```
typevar : alpha ;
dec listcount : list(alpha) -> num ;
--- listcount(nil) <= 0 ;
--- listcount(x :: y) <=
      1 + listcount(y) ;
```

This program counts lists of objects of type alpha, where alpha can be any type that Hope supports. The Imperial College implementation supports types num (which are positive integers only), char (characters), and truval (Boolean truth values), together with lists and sets of those types. So we could run the program either as

```
>: listcount([3,4,5,6]) ;
>: 4 : num
```

or

```
>: listcount("zeitgeist") ;
>: 9 : char
```

or even

```
>: listcount([true,false,true,true,
   false]) ;
>: 5 : truval
```

Note that the terminating semicolon is essential for all inputs to Hope, that list arguments need their square brackets, and that a literal string like "zeitgeist" is treated by Hope as an alternative way of writing a list of char. The declaration of typevar alpha is actually redundant because alpha and beta are predeclared in the system and ready for use.

If you enter listcount ; alone without arguments, Hope returns its type, list(alpha) -> num. It's generally true that all defined objects will return either their type or status (in the case of switches like trace and time) if they are entered without arguments.

The program can be entered merely by typing each line at the prompt, followed by a carriage return. Hope allows you to format the code with spaces and tabs for indentation and it "remembers" such formatting.

There is no block structure (as is found in Pascal or C) and no marker for the end of a program. New recursion equations can be entered at any time (like adding lines to a BASIC program), and they are appended to the end of the program, the equations being stored in the order in which they were typed.

Type and syntax checking are performed immediately upon program entry. A recursion equation that contains either a type or syntax error will not be accepted and must be retyped correctly.

The error messages are in plain English; for example:

```
>: --- listcount(x) <= 0 ;
%HOPE Types incompatible
list(alpha)
num
```

The two offending types are printed out below the message (%HOPE indicates a message from the Hope interpreter).

The philosophy of Hope is that as many errors as possible can be caught upon entry; run-time error reporting is much less powerful, although it can tell you that no matching equation was found for a particular argument, thus inviting you to add a suitable one.

Some run-time errors, especially those involving memory management, may trigger more cryptic error reports from the underlying Pascal run-time system.

A program can be inspected by typing the command display ;, which lists the source for all the user-defined functions on the screen, or by display listcount ;, for instance, which just lists listcount.

The listing might not be in the order in which you entered the program, as operators, typevars, and data declarations are listed first before all function declarations. It's also possible that in the listed version, Hope may have altered the parentheses, adding some extra levels on occasion.

The modify command allows a limited editing of programs. If modify listcount ; is typed, Hope offers the declaration line first, thus permitting its type specification to be altered (you can't actually delete the declara-

(continued)

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tion, so once declared, a function is there to stay). We could, for instance, change listcount to list(num) -> num.

Then the equations are presented one after another, and a menu offers the choice of deleting or replacing each equation, or inserting a new one before or after it.

It is not possible to edit the text of an individual equation, which must be retyped in full if necessary—hence the value of a separate editor.

Hope programs can be traced or timed by commands called, oddly enough, trace and time. Tracing can be applied to a list of named functions (e.g., trace listcount ;) or it can be applied to everything (trace all ;). It must be switched on with trace on ;. Timing is switched on in the same way and returns the execution time in 10-millisecond units, rather too coarse grained to time very simple evaluations, which always return 0.

The save command saves the contents of the workspace to disk under a filename, which is given the default extension of .HOP automatically. Such files can be read back in using the load command. The files contain plain ASCII (American Standard Code for Information Interchange) and are accessible to any standard software tools.

One feature of these commands that may cause surprise at first is that in a file written by save, function declarations are separated from their equations and saved at the beginning of the file. This is to ensure that when a file is read back in, all functions will have been legally declared before they are used in other function bodies. Unlike LISP, Hope does not tolerate the use of a function's name before it has been declared.

Input/output (I/O) is often rudimentary in functional languages, but Hope supplies an interface to PC-DOS on two levels. Character I/O is provided by the built-in functions putch and getch, while file I/O can be performed by treating named PC-DOS devices as "lazy lists" (that is, lists whose elements are only produced on demand).

I've found SideKick to work well as an editor for Hope, apart from the annoying fact that when an edited file is loaded, the new equations don't overwrite the previous versions but are appended at the end of the program.

The definition of Hope forbids "overlapping left-hand sides," that is, more than one equation with the same left-hand side. The interpreter used at Imperial College currently ignores them (a limitation that is clearly documented) and executes the first version, which in my case is the unedited version.

This makes deletion of the old versions necessary before or after loading the new versions, although in practice I find it easier to restart Hope from DOS and then load (I'm using a RAM disk, which makes this a fast operation).

A more satisfactory behavior in an interactive interpreter, short of an integral full-screen editor, would be for new equations to overwrite "overlapped" old ones just as is done by BASIC lines with the same line number. Alternatively, if this is unacceptable, a global delete command to remove whole definitions is needed. Using one of these solutions, the system could provide interaction as fast and convenient as the best of BASIC or FORTH systems.

The full solution is the implementation of modules, which Victor Wu is incorporating into the next version. Sealed program modules will be able to be saved, loaded, and killed, thus tidying up the ergonomics at the same time as providing a powerful mechanism for hiding private program and data definitions.

Don't expect miracles on the performance front. Functional languages are generally slow and memory-consuming on conventional hardware, and Hope is no exception. I tried running the Sieve of Eratosthenes benchmark and discovered that, even using "lazy evaluation" for the number list (lcons rather than ::), only primes up to 174 could be computed in the available workspace. If you use an "eager" list,

(continued)

only 76 can be handled.

The point of including this information is to dissuade anyone who might think they're going to use this free Hope to write a real-time airline booking system. Instead, regard it as a sampler with which to investigate the very real advantages of the functional programming style; then you'll be ready for the next generation of parallel hardware that will make such languages a practical proposition.

In summary, this system is pleasant to use and remarkably complete, given that this is a "laboratory" language hitherto confined to mainframes and superminicomputers. The only features omitted, apart from modules, are "overloaded" operators (e.g., using the same operator + for adding numbers and concatenating strings), prefix and "distfix" operators, and certain of the more advanced set and mapping functions.

Victor Wu told me that these will be included in the next version, which will be able to use more than 128K bytes of memory. A Macintosh version (Fat Mac only) with a full windowing editor is in preparation and due to be released sometime this year.

Declarative Books

Until very recently there has been a noticeable dearth of readable books on the subject of declarative programming. A few years ago the only such book available to the nonacademic reader was *LISP* by Patrick Henry Winston and Berthold K. Horn (Reading, MA: Addison-Wesley, 1981). The reason is simply that most of the work on such languages occurs in universities, which tend to disseminate information through papers rather than books.

Two books published recently in London, one on functional and the other on logic programming, are very welcome additions to the understocked library. Both books are pitched at undergraduate computer science level but are written clearly enough to be accessible to any experienced programmer. A proviso is that both books contain a formal mathe-

(continued)

matical chapter, but this could be skipped over without too much loss of sense.

Principles of Functional Programming by Hugh Glaser, Chris Hankin, and David Till is published by Prentice-Hall International (1984). The authors are lecturers at London University.

The book starts on a commendably down-to-earth note, by looking at examples of top-down program design in plain English. In the subsequent chapter, the authors show how a simple and elegant functional language called SUGAR emerges quite naturally from these program specifications. The remainder of the first part of the book then discusses the syntax of SUGAR, profusely illustrated with example programs and exercises for the reader. One of the examples concerns functional turtle graphics, which is a welcome departure from the mathematically biased problems that authors in this field have a tendency to rely on.

The second part of the book begins with a chapter on Alonzo Church's *lambda-calculus*, which is the mathematical underpinning of functional languages. Nonmathematical readers may prefer to skip this, but I found it quite fascinating, if only to find out where that cryptic word LAMBDA in LISP came from. More important, it clarifies the reasons why functional programs are susceptible to mathematical analysis and transformation, while procedural programs are not, in general.

A subsequent chapter explains the development of an interpreter for SUGAR written in SUGAR, and this leads into a discussion of three different models for machines (virtual or real) that have been devised to execute functional languages. These architectures (SECD, SK Reduction, and Data Flow) are described by algorithms written in a mixture of pseudo-Pascal and plain English (far more approachable for "outsiders"), which are sufficiently detailed to serve as a guide for serious readers who wish to experiment with real programs. The section ends with a chapter on formal semantics, which will make little sense to computer novices.

The third part of the book consists of a survey of some existing functional languages. The largest chapter is devoted to FLISP, which is a functional subset of LISP, and smaller sections to KRC, Hope, and John Backus's FP systems. Useful appendixes include rules for translating SUGAR programs into FLISP and the listing for an FP system written in FLISP.

While the book is not a tutorial in any particular functional language, it provides an informed overview and a rationale that could be of use not only to potential implementors but to anyone who plans to learn functional programming. The functional style of programming is very different from the procedural style most of us have grown up with; for myself at least, understanding the reasons behind it makes the transition a lot easier.

The second book, *Introduction to Logic Programming* by Christopher Hogger (Academic Press, 1984), is more theoretical and, to the nonacademic reader, more difficult than the first, although it covers analogous ground. It is not specifically about Prolog, though it concedes that Prolog is the one widely used logic-programming language.

Like *Principles of Functional Programming*, it starts from first principles, with an explanation of logical predicates, interpretations, and implications. Some of this treatment is quite formal, but the author suggests parts that may be skipped on first reading. The discussion of inference leads to discussions of *resolution* and *unification*, the techniques that permit computers to solve logic problems.

Attention is then directed to logic programs on computers, with a discussion of the standard strategy of a logic interpreter, the structure of logic programs, and data structures. I learned a lot from this section, particularly about control flow in logic programs, which is almost a taboo subject in Prolog tutorials; it came as something of a surprise to read about sequencing, branching, and iteration, as well as recursion. The difficult sub-

(continued)

jects of nondeterminism and negation are covered in some depth.

Two chapters cover the verification of correctness of logic programs and the synthesis of programs from specifications—the area in which the strongest claims are made for the superiority of logic programming over the conventional kind.

A chapter on implementation is well illustrated with structure diagrams and algorithms in pseudo-Pascal. Special attention is paid to the pursuit of efficiency and to techniques for conserving memory or processor time (almost always a trade-off).

The book ends with a chapter called "Broader Contribution to Computing," which discusses the influence of logic programming on computing theory, and the various implementations of Prolog worldwide, including the Japanese Fifth Generation Project.

My conclusions about the first book hold true for this one, too; knowing the background can only help in learning the languages. I found *Introduction to Logic Programming* a more difficult book, but that's because I find logic harder than programming. The specialist will appreciate that this is the first book that covers all aspects of the field, and apparently it is currently the only book that covers the implementation of Prolog.

I highly recommend both books to anyone who wants to find out what is happening in the evolution of programming and who isn't afraid of some rigorous thought.

MacProlog

In the December 1984 BYTE U.K. ("Prolog on Microcomputers," page 355) I described micro-PROLOG for CP/M-80 machines. Frank McCabe, one of its authors, recently loaned me a beta-test copy of MacProlog, his implementation for the 512K-byte Macintosh.

MacProlog has many improvements over the older micro-PROLOG, not the least of which is that it compiles rather than interprets; this, combined with the Mac's 68000, makes it very fast indeed for an artificial-intelligence language. McCabe has taken the trouble to fully integrate Prolog with the Macintosh user interface, which makes it much easier and nicer to use, too.

It's based on sigma-PROLOG, a UNIX version of micro-PROLOG, and one of the great improvements in sigma-Prolog is that you can use long variable names instead of *x*, *y*, and *z*. What's more, the system remembers variable names so that they are not all changed when you list a program as they were in micro-PROLOG. The naming convention is that all variables must begin with an underscore.

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Compared to micro-PROLOG, MacProlog syntaxes are better controlled and less potentially confusing thanks to the Mac interface.

This enhancement is apparently the product of much blood, sweat, and tears at Logic Programming Associates. I hadn't realized until I read Hogger's book (discussed previously) that the capricious treatment of variable names stems from the nature of the logical inference process itself and was no mere whim of the implementors; the cure was not trivial.

On booting up the Mac and opening the sigma-PROLOG icon, the top menu bar offers the choices File, Edit, Search, Program, Windows, and Queries. The only window open on the screen is called Default Output Window.

Programs are written using a new window for each separate relation defined. To write a program you pull down the Program menu and select New, which opens a new window. The relation definition is typed into this window, and it is then named by selecting Relation Info from the menu.

Of course, the full editing power of the Mac interface, including Cut and Paste, is available during this input, which is a huge improvement over the line-oriented editor of micro-PROLOG. The standard Mac Edit menu has an added option that checks for unbalanced parentheses in a selected text.

When finished, the new code can be syntax-checked and compiled by selecting Check Program from the Program menu. Compilation also occurs automatically when a query is made to a relation that has been edited; it's very quick.

When a relation window is named, MacProlog puts this name onto the Windows menu. The current window can then be hidden to avoid the screen becoming too full of windows, and it can be reopened by selecting from the Windows menu.

In practice, you will more likely want to use Search to find a particular relation name, whereupon its window is automatically opened and made current. Search can also do global search and replace on any name.

There is no command line input to MacProlog at all; all interaction is performed through menus and templates. To actually run programs, you pull down the Queries menu, and choose either Which or Command.

Choosing Which produces a template box for you to enter a query into, and this query becomes the default until altered so you can evaluate it repeatedly with a single button press. Trace and All Answers options can be set by buttons in the template box. Command produces a similar box for entering system commands.

All the answers to a query appear in the Default Output Window, followed by the time taken for the evaluation.

Errors are reported in a Macintosh dialog box, which offers the options to Continue, Fail, or Succeed the query, and presents a Prolog description of the problem.

MacProlog, like micro-PROLOG, comes with a choice of different syntaxes. Although there are actually more of them (no less than seven), they are much better controlled and less potentially confusing thanks to the Mac interface. Instead of loading modules (and forgetting which one is loaded), a Syntax option is selected from the Program menu.

This presents a control panel, similar to those used for printing and selecting type fonts. You can see at a glance which syntax is selected, and you can change it by clicking on a button.

The syntaxes available are Micro (for compatibility with micro-PROLOG), Edinburgh, MITSI (a new simplified English-like form for novice programmers), Prefix, Core, and Lambda, which was not implemented in the beta-test version.

Core syntax is what the compiler

(continued)

uses (only needed by serious hackers) while Prefix is the preferred syntax for experienced users; it looks like this:

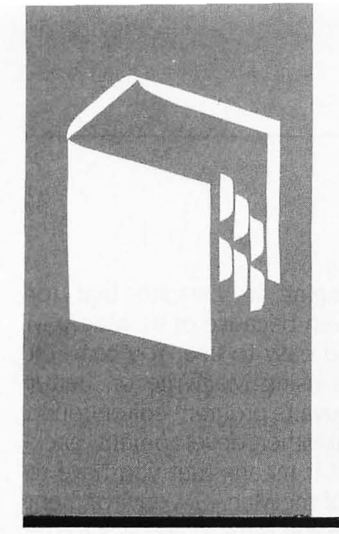
```
can_buy(_person _thing)
  if in_stock(_thing)
  & LESS(price(_thing)
  funds(_person))
```

A final option in the Syntax panel is Interpret; this enables interpretation instead of compilation, which permits greater flexibility in tracing and debugging at the expense of speed.

The built-in predicates of MacProlog have been expanded to include a whole set for controlling Mac menus and dialogue boxes. It's possible for the user to create pull-down menus and attach Prolog programs to them to create Macintosh-style applications.

The test version of MacProlog has 24-bit integer arithmetic only, but later versions may have floating-point and transcendental functions as UNIX sigma-PROLOG does. Modules are not implemented in the test version.

In summary, MacProlog looks like a nicely integrated product that goes a long way toward the sort of friendly programming environment available on $30,000 LISP machines. The U.S. distributor is Programming Logic Systems, 31 Crescent Dr., Milford, CT 06460, (203) 877-7988, but I have no date for its release. ■



According to Webster

Greetings and Agitations

Methods
Turbo Pascal 3.0
Copy II Mac
MacTools
MacASM
MacModula-2
Megamax C
QC-20

BY BRUCE WEBSTER

Like last month, this month's column will talk mostly about Macintosh stuff, although it does start out with a few non-Mac products. These columns will probably continue to contain about 60 to 70 percent Mac-related items since most of the hardware and software that comes in is for the Mac. Also, there is substantial coverage of CP/M, MS-DOS, and IBM stuff elsewhere in BYTE.

METHODS

In the May issue of BYTE, Tom Yonkman and I wrote a product preview of Methods, a version of Smalltalk for the IBM PC from Digitalk Inc. ("Methods: A Preliminary Look," page 152). Methods is now being shipped. It comes with two manuals: *Smalltalk Language Guide* (51 pages) and *Environment Guide* (67 pages). The first manual is unfinished (four chapters are simply "to be completed" pages), and the documentation itself is terse and jargon-laden.

If you're already familiar with Smalltalk, you probably won't have much of a problem with Methods. If you're not familiar with Smalltalk, then be warned: This package is not an easy one to sit down and use on your own. You should buy it only if you are very interested in Smalltalk and are willing to put in a lot of time unlearning conventional software development and switching over to the Methods/Smalltalk environment.

TURBO PASCAL 3.0

About two years ago, Philippe Kahn of Borland International started something of a software revolution by releasing Turbo Pascal for $49.95. Very few people believed the claims in the ads; I sure didn't. The product seemed too good to be true, especially in light of the JRT Pascal fiasco. I was writing a Pascal column for *Softalk for the IBM PC* at the time, so I asked for a review copy, fully intending to rip it to shreds. Instead, I wrote such a glowing review that excerpts were later quoted in Turbo Pascal ads. Turbo Pascal became a software hit, selling some 250,000 copies in two years, an amazing figure for a computer language.

Borland has continued to improve the product over that time, releasing version 2.0 last year. Now version 3.0 has come out, with a number of fixes, a large list of improvements, and a 376-page manual (about 100 pages longer than the 2.0 manual). It also comes with a slightly higher price tag of $69.95. Turbo Pascal is best known for its small size, incredible compile speeds, and fast execution times. Version 3.0 is still small (less than 40K bytes for the compiler *and* editor) and is actually faster in compile and execution times. On top of that, the MS-DOS version has a large assembly-language graphics library (including, but not limited to, a turtle graphics implementation). The MS-DOS version also provides better support for DOS (disk operating system) 2.0 and 3.0 file I/O (input/output) and directory calls. A BCD (binary-coded decimal) version is available, designed primarily for financial applications where you need large precision (18 digits) and minimal round-off error. And, of course, an 8087 version of 3.0 is out as well.

Turbo Pascal is not a perfect implementation. Program code is limited to 64K bytes resident at any one time. You can use overlays and chaining to get around that, but it can still make for awkward development. Libraries are not as convenient to use as in UCSD Pascal; ditto for assembly-language routines. But it is fast, small, and cheap; it has a tremendous number of built-in routines to do low-level system work; and it's fun to play around with. The language and the documentation have improved with age. Even at the increased price, it's probably still the best software deal on the market.

A BRIEF ASIDE

In the interests of integrity, I would like to point out that I have had one financial dealing with Borland International. Last October, just as I was quitting my job, Philippe Kahn

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Bruce Webster is a consulting editor for BYTE and a charter member of the PMS Commandos. He can be contacted c/o BYTE, 425 Battery St., San Francisco, CA 94111.

called me with a problem. Borland had contracted with an author to write a book on Turbo Pascal. For various reasons, that author couldn't complete it; Philippe, familiar with my Pascal column in *Softalk for the IBM PC*, asked if I could help finish the book. I accepted the job (for a flat fee) and in two weeks wrote parts II and III of *Turbo Tutor*, basing it largely on my *Softalk* columns. Since I receive no royalties from sales of *Turbo Tutor*, my wallet doesn't really care if you buy it or not (though my ego has some concern). And, of course, the same applies to Turbo Pascal itself.

Copy II Mac/MacTools

Since most of the Macintosh application software is copy-protected, it was inevitable that a Mac bit-copying program would soon appear. It did—Copy II Mac from Central Point Software—and it's good. I tried it out on almost every piece of copy-protected software I had, and all the copies seemed to work just fine. What's more, the package includes MacTools, a file-manipulation and file-editing routine that lets you set attribute bits (invisible, locked, protected) for files, as well as view and edit them in hexadecimal/ASCII (American Standard Code for Information Interchange) format. And, yes, you can copy the Copy II Mac master disk using itself.

While I am strongly against software piracy—I don't give out software, nor do I receive it—I do feel the need to back up my master disks, especially for application packages. Copy protection on games doesn't bother me at all, but it can be a real pain on business or productivity software. The firm I used to work for had two business-type software packages on the market; neither was copy-protected, and both had instructions asking the user to immediately make backup copies and then store the masters somewhere safe (and leave them there).

If you're using copy-protected software on the Mac, you should have Copy II Mac to back up and preserve your masters. But please don't use it to steal.

Mac Development Software

Here's a quick look at three more development systems for the Mac and some benchmarks for the different languages. The three packages we're looking at are MacASM (from Mainstay), MacModula-2 (from Modula Corporation), and Megamax C (from Megamax Inc.). The benchmarks include these languages as well as several others we've talked about.

MacASM is a Mac assembly-language development system with a decidedly non-Mac interface. In fact, the user interface resembles nothing so much as your typical BASIC environment. Your statements have line numbers; you use commands like LIST, RENUMBER, DELETE, LOAD, SAVE, DIR, ASM, and RUN; and you edit by listing part of the program to the screen, then moving the cursor up and changing it. Despite that (or maybe even because of it), MacASM is fast and easy to use. You can edit programs using MacWrite or, better yet, Bill Duvall's program editor (found in several other development packages), but it means that you have to pop out of the MacASM environment each time you want to go back to the editor. Your best bet is to do the bulk of your program entry using a regular editor, then use the MacASM environment to debug your code.

The MacASM documentation is an 80-page manual explaining the system commands and assembly-language directives. You will need one or two books on 68000 assembly language, as well as *Inside Macintosh*, to do any serious development.

Because of the quick, familiar nature of its user interface, MacASM is a great tool for learning 68000 assembly language. What's more, you can create stand-alone applications (complete with resource files). According to Mainstay, more than 1000 developers are using MacASM to do just that. And, nicest of all, there are no licensing fees. If you do get MacASM, though, be sure to save your source code out often; whenever you start messing with assembly language, especially on the Mac, you stand a good chance of repeatedly crashing the system.

MacModula-2 is, of course, a Modula-2 compiler from the same people who build the Lilith (a

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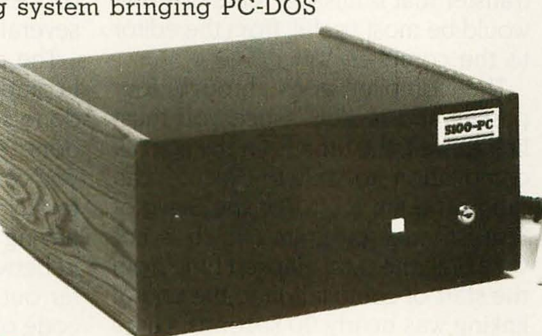
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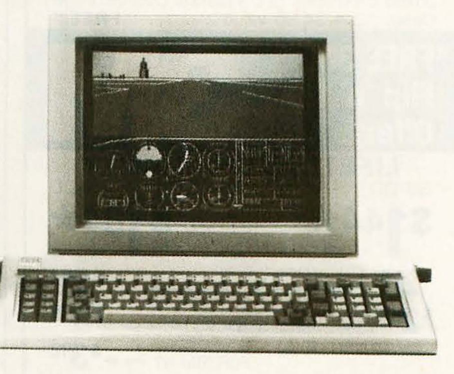
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ACCORDING TO WEBSTER

Modula-2–specific computer). MacModula-2 compiles down to m-code, a p-code that then runs on an interpreter. It runs under a standard Mac environment, with Bill Duvall's editor, a linker, a resource maker, and a large number of library modules. Most of these tools have a transfer menu that lets you go from one to another without having to go back into (and then out of) the Finder. Ironically, the one transfer that is missing is the one that would be most useful: from the editor to the compiler.

The compiler goes through four passes and is slow. Since you must link as well, the time from the start of compilation to able-to-execute can drag on quite a bit. For the Sieve of Eratosthenes program (which is not very big), the total elapsed time from the start of compilation to the end of linking was nearly 90 seconds. Large programs would be even worse, so your best bet is to really use the benefits of Modula-2 and break your programs up into small chunks, which you can compile, debug, and then leave alone.

The MacModula-2 documentation is an excellent, large (8½ by 11 inches) 550-page softbound manual, but it does not include a Modula-2 reference guide. If you're familiar with Pascal, you may be able to get by with just Niklaus Wirth's thin text, *Programming in Modula-2* (2nd ed., New York: Springer-Verlag, 1983); if you're not, you'll probably need to find a more extensive book. And, of course, you'll need *Inside Macintosh*.

Like MacASM and 68000 assembly language, MacModula-2 is probably an ideal environment for learning Modula-2 (short of owning a Lilith). Unlike MacASM, I'm not sure yet how well MacModula-2 works as a development system. Modula-2 itself is great for software development, but the long compilation and link times could lead to frustrated programmers wasting time staring at Mac screens. Since MacModula-2 uses an m-code interpreter, you can't produce true stand-alone applications; instead, you would have to distribute the m-code interpreter along with the object-code file. One piece of good news, though, is that Modula Corporation has dropped all licensing fees for MacModula-2.

Megamax C is one of several C compilers out for the Mac. It has basically the same editor and resource maker as MacModula-2, MacAdvantage, and a few other development packages. It also has a linker, a librarian, a code improver, a batch processor, a disassembler, and several libraries.

The compiler is *fast*. The first time I compiled the Sieve program, it was done so quickly that I thought I had done something wrong. And since you can transfer over to the linker or to any other program, you can avoid having to drop back into the Finder in between steps. You can also transfer out of the linker to your finished code or to anything else. Megamax C produces fast stand-alone code; its features include floating-point support, in-line assembly language, and a low price ($295).

I can't really compare Megamax to the other C compilers until I see them. What I heard of Megamax, though, was enough to convince me to go out and buy a copy, rather than wait for a review copy to show up. The manual, about 200 pages in a three-ring binder, is adequate; if you don't know C, you'll need an introductory text (*C Primer Plus* by Mitchell Waite, Steven Prata, and Donald Martin [Indianapolis, IN: Howard W. Sams, 1984] seems to be a good one) and (all together now) *Inside Macintosh*.

SOME BENCHMARKS

Mark Twain once said that there are three kinds of lies: lies, damned lies, and statistics. Benchmarks can fit into that list without much difficulty. Nevertheless, having all this development software, I decided to run the Sieve of Eratosthenes benchmark, just to get some rough comparisons. Table 1 shows the results.

All these benchmarks were run on a 512K-byte Mac with a Bernoulli Box, with one exception: The p-System benchmarks were done on a 128K-

(continued)


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byte Mac with two disk drives. In addition, I made the C, Modula-2, FORTH, and MacAdvantage:UCSD Pascal programs time themselves using the TickCount routine in the Toolbox. This didn't affect the execution times, but it did increase the compile and link times. Incidentally, the last column in table 1 is the execution speed in the previous column divided by the fastest time (2.9 seconds for MacASM, using a long-word fill). The result shows how many times slower that version was than the fastest one.

Comments? Megamax C is comfortably close to MacASM, especially since you can use the disassembler and in-line assembly language to speed up key sections. I suspect that the other C compilers are in the same ballpark. MacFORTH isn't that far behind, either. The p-code systems (MacModula-2, Mac p-System, MacAdvantage) are in the same ballpark, roughly 10 to 25 times slower than the C compiler. The exception is the native-code-generated version under the p-System, which competes well with the C compilers. MacPascal and MS-BASIC, which are here just for completeness, are 400 to 500 times slower than MacASM code.

For some non-Mac comparison, table 2 shows execution times (both regular and normalized for table 1) of the same program running under Turbo Pascal on a 256K-byte Compaq with two floppies. The compile times (which were in the standard Turbo RAM-to-RAM mode) were all about 0.8 second. (No, that's not a typo: It was four-fifths of a second.) Incidentally, the Turbo defaults are no user interrupt and no range checking, so the 14.5-second time is what you would normally get. You would have to deliberately set the {$U+} and {$R+} options to get the slowest speed; looking at the table, you can see why.

FOR MAC DEVELOPERS

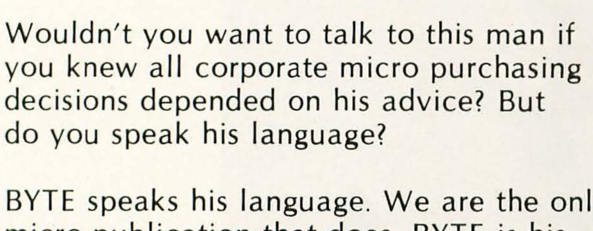
I have found (along with a lot of other people) what is probably the best magazine for Macintosh software developers. It's a homebrew journal called *MacTutor* (formerly *MacTech*). It's not fancy or slick, but each issue (monthly, about 44 to 48 pages) is full of explanations of the Mac's intricacies. The format is a series of columns dealing with the different languages: FORTH, C, Pascal, Modula-2, BASIC, 68000 assembly language, and more. Worth its weight in 3½-inch floppies. Back issues are available.

UPDATE: SOFTECH MICROSYSTEMS

Warren Williamson, who does the copy editing on my column, must be

(continued)

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getting upset with me. You see, this is the second month in a row where I've had to make major changes to the author's proof due to developments in the real world.

Last month, I had to change a couple of paragraphs where I took SofTech to task over licensing fees for MacAdvantage:UCSD Pascal. You see, SofTech had dropped all licensing fees and (according to what they told me) had cut the price as well, from $295 to $119. This was all to go into effect July 1, which is when my first column was going to show up.

A few weeks after having made that change, word came that SofTech Inc. was going to sell off SofTech Microsystems. I talked with officials at SofTech Microsystems, who assured me that all the product changes they had told me about were going to go into effect anyway. . . except for the drop in price for MacAdvantage. In short, I don't know *what* SofTech is going to charge for MacAdvantage. So my first piece of news is that you'll have to contact SofTech yourself to find out exactly what the status is for MacAdvantage, as well as the products I'm going to mention in the next few paragraphs.

Second, SofTech is reorganizing the IBM PC p-System into three separate packages: the basic MS-DOS–hosted p-System, with editor, UCSD Pascal compiler, and filer; an assembler/native-code-generator package; and utilities package (disassembler, debugger, etc.). Furthermore, each package will sell for only $49.95 (shades of Borland!). Since this is the MS-DOS–hosted version of the p-System, your files are on DOS-formatted disks, and your programs can read and write DOS files. Since the p-System offers more sophisticated memory management and library facilities than Turbo Pascal, and since p-code is very compact, this might be an attractive alternative for those of you writing large Pascal programs on the IBM PC. Again, there has been a change in licensing policy: Any program that is released as public-domain software or shareware ("Send me $xx if you like it") requires no licensing fee. Any commercial product—something that is sold through mail order or dealers and that has a suggested list price—still has to pay the standard fee.

And Now for Something Completely Different

This same SofTech, a company known mostly for a runner-up development system, is releasing a product that may have reverberations throughout the industry much on the same order as Turbo Pascal and SideKick. A few years ago, two programmers developed and shipped an integrated software package for the Apple called The Incredible Jack. Their success got them some venture capital, and they wrote an improved version for the IBM PC, called Jack2. Then the rumblings about Ovation, Symphony, and Framework started, and the venture capitalists got cold feet. SofTech now owns the product; its people have improved it even more and plan to start shipping it on the 1st of July under the name TeamMate. That would be ho-hum news at best, except for one important change: A package that used to cost $500 will go out on the market for $69.95. Yes, you saw that right. Sales of Symphony and Framework have been sluggish; what will happen when TeamMate hits the shelves?

Update: Mac Mass Storage

I talked last month about the Quark QC-10 hard disk for the Apple II, Apple III, and Macintosh. Since then, Quark has announced the QC-20, which is a 20-megabyte version of the QC-10. Quark has also released the Apple Pascal (version 1.2) support software, but since I no longer have

(continued)

Table 1: *Macintosh Sieve benchmarks.*

Language	Compilation	Linking	Execution	Normalized
MacASM	1.1	--	3.1	1.1
long-word fill	1.1	--	2.9	1.0
Megamax C	3.2	27.8	6.5	2.2
and improver	+6.8	--	6.2	2.1
register vars	3.1	26.8	4.4	1.5
and improver	+6.4	--	4.2	1.4
MacFORTH (1.1)	1.3	--	25.3	8.7
using FILL	1.3	--	20.0	6.9
MacModula-2	46.4	22.8	84.8	29.2
range check off	44.6	22.5	71.6	24.7
Mac p-System	16.9	--	92.6	31.9
no rcheck, FillChar	18.8	--	59.6	20.6
native code gen	18.6	19.3	6.5	2.2
MacAdvantage	22.6	--	104.1	35.9
range check off	22.4	--	88.6	30.6
and FillChar	22.7	--	69.1	23.8
MacPascal (Beta)	--	--	1235.0	425.9
MS-BASIC (2.0)	--	--	1294.0	446.2

Table 2: *Sieve execution benchmarks on the* IBM PC*-compatible Compaq. The program is identical to the one used to generate the benchmarks in table* 1.

	Execution	Normalized
Turbo Pascal (3.0)	173.8	59.9
user interrupts turned off {$U-}	25.9	8.9
and range checking turned off {$R-}	14.5	5.0
and using FillChar	11.6	4.0

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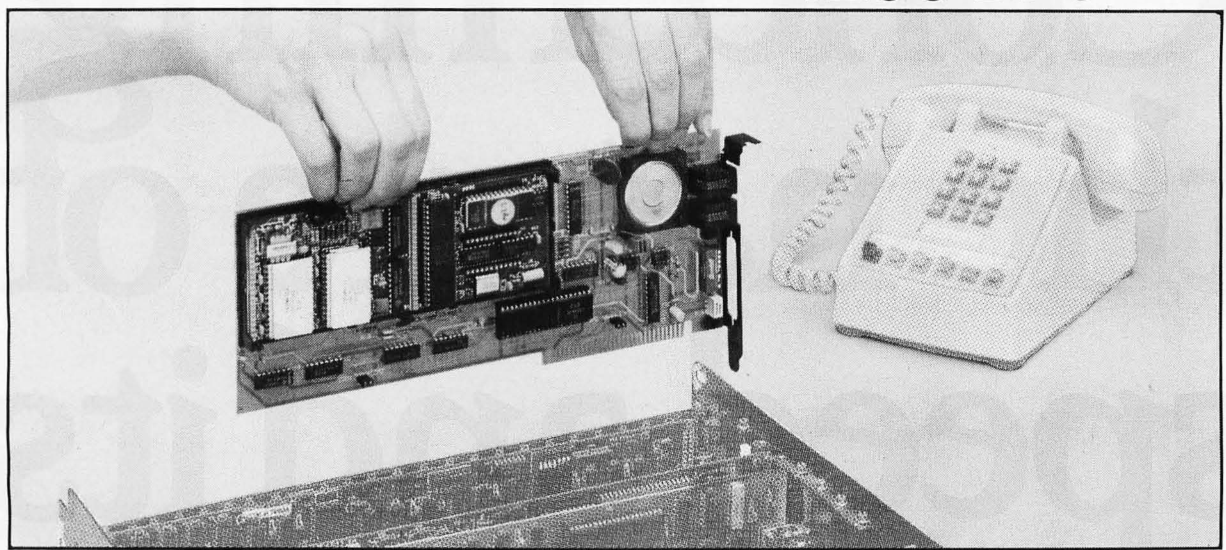
a QC-10 to test it on, I can't tell you how well it works.

I also talked about the Iomega Bernoulli Box (which, thankfully, I still have). I have used the partitioning software, which let me divide each 5-megabyte disk into five 1-megabyte "disks." A simple mount program then lets me decide which "disks" are mounted or dismounted. It isn't as flexible or convenient as the Quark Volume Manager, but it's a lot better than having to work with a single 5-megabyte disk. Iomega also announced a slave drive for the Mac Bernoulli Box. It costs $1195, plugs into the back of the Box, and gives you another 5-megabyte drive. Great for backups; if I can get one on review, I'll let you know how it is.

COMING EVENTS

Next month, I hope to take a good look at SofTech's integrated package, more Mac C compilers, and other odds and ends. Until then, hang loose, and I'll see you on the bit stream. ■

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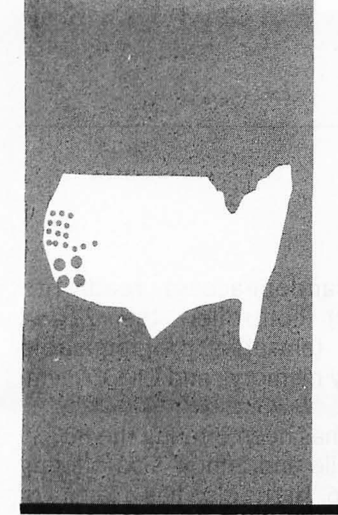
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New Microprocessor Chips

The iAPX 386, the 80C86, and the AT Probe

BY PHILLIP ROBINSON

This month I'll look at an excellent example of the activity in the chip trade: the iAPX 86 family from Intel.

First, there's the 80386. This 32-bit microprocessor has two important ancestors: the 8088, which is in the IBM Personal Computer (PC) and PC XT, and the 80286, which is in the IBM PC AT (see the review of the IBM PC AT by Alan Finger, May BYTE, page 270).

Then there is the 80C86. The CMOS (complementary metal-oxide semiconductor) process used to make the 80C86 uses far less power than the process used to make the standard 8086; the CMOS technology improves both the portability and reliability of systems.

I'll also look at Atron's AT Probe, a "hardware-assisted software debugger" for the 86 family. This device lets software engineers be software engineers, rather than candidates for burnout, by helping to trace, isolate, and record software bugs.

THE IAPX 386

The 80386—the first 32-bit member of the iAPX 86 family—is almost here, after years of speculation. Although most of the big semiconductor makers are interested in the 32-bit microprocessors, the recent battle has been largely fought between Intel's 8086 family and Motorola's 68000 family.

Intel's first run in the 32-bit arena was the 432, a chip that just recently was given the ax. Intel refers to this experimental chip as a learning experience; the 432 didn't turn up on the shelf in any computer store. It was optimized to run Ada, and Intel trumpeted it as a chip of the future. Today it's just a philosophical conversation piece.

But now there is a real 32-bit microprocessor. Many people assume that the 80386 is the front runner for a 32-bit IBM PC for the following reasons: IBM was first to carpet the world with 8088 boxes, it is now selling as many 286 machines as it can make, and it has acquired a big chunk of Intel.

If IBM doesn't get to the 386 first, you can bet that plenty of other companies will. Those designers who have been pitting 8086 and 80186 boards against IBM's 8088 are ready to grab the first working 80386 to gain an advantage in the marketplace.

Here are some details I garnered from the advance information sheet on the 80386 (dated October 1984; order number 231247-001).

The iAPX 386 (the official name for the 80386) is made using CHMOS III technology. CHMOS is Intel's latest version of the CMOS process. The 386 is pipelined, has a high-bandwidth 32-bit bus, and supports full 32-bit addressing (4 gigabytes of physical space, 4 gigabytes per segment, and 64 terabytes of virtual address space per task).

The 386 also has memory management and protection (compatible with the 286), virtual-memory support, caches, and paging (optional) all on chip. It can handle 8-, 16-, and 32-bit data, has a multiple-coprocessor interface, and supports integrated multitasking.

The 386 is *object-code* software-compatible with the 86, 88, 186, 188, and 286. The 386 instruction set is a superset of the 286 set. All instructions are extended to support the 32-bit addresses and operands. As is typical in new-generation microprocessors, new instructions have also been added. That means 8088 programs (such as those for the IBM PC) should run without recompilation on an 80386 box.

The 16-bit general-purpose registers found on the 286 are extended to 32 bits on the 386. In addition, Intel has added two segment registers for simultaneous manipulation of multiple data structures.

Address generation is the same as on the other 86 family chips: An optional base is added to an optional index and an optional displacement.

The on-chip memory management of the 386 will save designers from having to use a

(continued)

BYTE West Coast is prepared monthly by BYTE's editors and staff in San Francisco and Palo Alto. Correspondence should be addressed to BYTE West Coast, BYTE Magazine, 425 Battery St., San Francisco, CA 94111.

Intel is also showing off its new versions of the 8088, 8086, and peripherals.

memory-management chip. The hardware protection of memory areas, with its four privilege levels, is the same as on the 286. Separate program tasks can be isolated from one another.

The 386 is available with either a 12- or 16-MHz clock; Intel figures that the 386 offers two to three times the performance of the 286. Also, Intel is promising an 80387 numeric coprocessor that will be compatible with the 8087 and 80287 but will operate at four times the 287's speed.

So, when can you get one? Sample chips should be available in the fourth quarter of 1985. Production is scheduled for mid-1986. If you're interested, get the literature; there should be more available by the time you read this. Unfortunately, unless you're a prized Intel customer, paper is all you'll probably be able to get for a while yet.

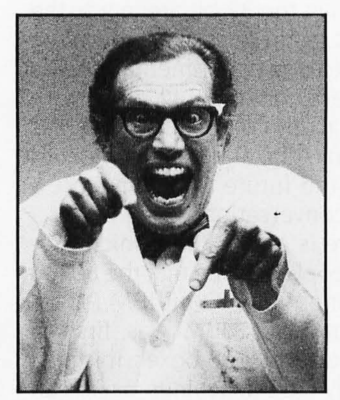
LOW POWER AND LONG LIFE: THE 80C86

Intel is also showing off its new CMOS versions of the 8088, 8086, and peripherals. The 80C88 and the 80C86 (with speeds up to 8 MHz) are accompanied by an 82C84A clock, 82C88 bus controller, 82C59A interrupt controller, 82C54 timer/counter, 82C55A peripheral interface, 82C08 dynamic RAM (random-access read/write memory) controller, the 27C64 EPROM (erasable programmable read-only memory), and CMOS memories.

Harris has been offering the 80C88 for a while and is now also offering an 80C86. Harris also has a family of chips including the 82C52 serial-controller interface, 82C54 programmable interval timer, 82C55A programmable peripheral interface, 82C59A priority-interrupt controller, and 82C37A DMA (direct memory access) controller. To add to the stew, Harris has CMOS gate arrays, bus-support circuits, RAMs, and PROMs.

Why is everyone so excited about CMOS? As a September 1983 BYTE article ("Inside CMOS Technology" by Martin B. Pawloski, Tony Moroyan, and Joe Altnether, page 94) pointed out, the enormous drop in power re-

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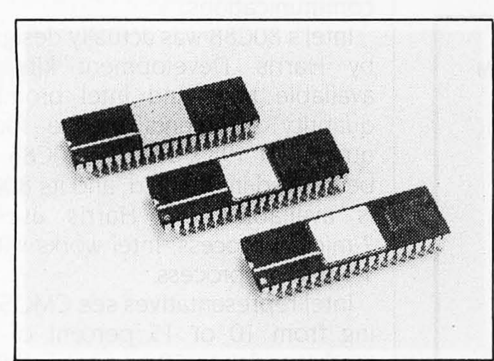
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[1]Requires RTOS or iRMX-86. All Intel compiler names and iRMX-86 TM Intel Corp.

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quirements from old-fashioned NMOS (negative-channel metal-oxide semiconductor) to CMOS has many advantages. Not only do you have to supply only one-tenth as much power to CMOS as to NMOS chips, but the chips run much cooler. That temperature change means a much higher reliability, longer chip life, and no need for fans and other cooling apparatus (in many situations). CMOS even yields greater noise protection.

The Intel and the Harris chips have the same power ratings. The 80C86's power use is rated at 10 milliamps per megahertz (mA/MHz). In fact, the CMOS 80C86 can run right down to zero speed. In that standby state, without losing any data, the 80C86 uses less than 500 microamps. An NMOS circuit uses the same amount of power whether it is running slowly or quickly; an NMOS 8088/8086 typically uses 300 mA of supply current.

Intel and Harris hope the advantages of CMOS will move them beyond the portable-system environment into desktop machines and telecommunications.

Intel's 80C88 was actually designed by Harris. Development kits are available now, and Intel promises quantity shipments in the fourth quarter of 1985. Harris's 80C88 has been used in the field, and its 80C86 is available now. Harris uses a 2-micron process; Intel works with a 1.5-micron process.

Intel representatives see CMOS rising from 10 or 15 percent of the market today to 50 percent by 1988. In 10 years, they think HMOS (the Intel version of NMOS) will be gone.

IRON HELPS MAKE THE 80286 WORK: THE AT PROBE

Debugging software frequently takes more time than writing it. And there's good reason to believe that the new generation of chips, including the 80286, will make debugging tougher than ever before. Atron, a small firm in Saratoga, California, is making a good living battling that debugging problem.

Founded in 1983 by former Intel employees, Atron makes a variety of software and hardware debugging aids. It has become very successful because of its PC Probe, a debugger that consists of both an add-on card for the IBM PC and some software. A ribbon cable from the card plugs into the 8088 socket; the hardware multiplies the power of the software debugger.

Now Atron is peddling the AT Probe. Like the PC Probe, it consists of both an add-on card and software. However, Atron couldn't just plug a cable from the card into the 80286 socket of the PC AT. The 80286 in the PC AT uses a nonstandard package (a pin-grid array), and a corner of it is

(continued)

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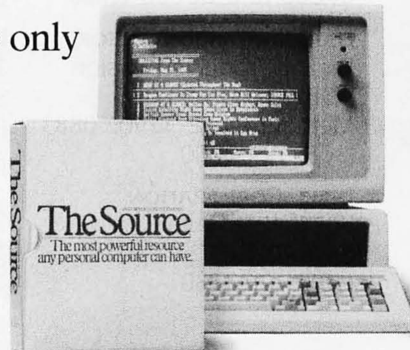
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tucked underneath one of the system's disk drives. However, because the PC AT's socket for the 80287 is accessible and is connected in parallel to the 80286, Atron decided to use it for the interface.

The $2500 Atron system competes with debugging and development systems costing between $30,000 and $50,000 from companies such as Intel and Hewlett-Packard. Intel's system depends on a special bond-out version of the 286 chip that brings internal signals to the outside for analysis. Atron handles the signal analysis in a different way. The AT Probe saves all the signals from the last 2048 instructions in its bank-switched 1-megabyte on-board memory. When the 286 hits a trap, the system returns to the user and—on the way—analyzes the signals.

The AT Probe can reverse-match its recorded real-time signal trace data to high-level-language source code (C, for example). This lets you use the AT Probe menus to step through a high-level-language program and yet watch the machine-level effects. This single stepping shows upcoming code, emulates instructions, lists variables and contents, and even describes jump decisions. The AT Probe will

The AT Probe can reverse-match its recorded real-time signal trace data to high-level-language source code.

also give complete 287 floating-point support.

The AT Probe intercepts processor signals and can trap or trace *anything* that happens with those signals. It even has performance- and timing-analysis software with which you can create histograms showing where a program spends its time.

Atron feels that many aspects of today's popular programs—dynamic memory allocation, complex interrupts, operating-system-protected modes—require hardware to seize and manipulate data that could evade yesterday's software debuggers. ■

COMPANIES MENTIONED

80C86 and 80C88 chips:
HARRIS SEMICONDUCTOR
Digital Products Division
POB 883 MS 53-035
Melbourne, FL 32902-0883
(305) 724-7000

INTEL CORPORATION
2625 Walsh Ave.
Santa Clara, CA 95051
(408) 496-4580

iAPX 386 chip:
INTEL CORPORATION
3065 Bowers Ave.
Santa Clara, CA 95051
(408) 987-8080

PC Probe and AT Probe:
ATRON
20665 Fourth St.
Saratoga, CA 95070
(408) 741-5900

C·I·R·C·U·I·T C·E·L·L·A·R F·E·E·D·B·A·C·K

Conducted by Steve Ciarcia

VOICE-STORAGE PACKAGE

Dear Steve,

In any of your Circuit Cellar articles, have you used a voice-storage package operating from an analog microphone? I am interested in such a package capable of storing and playing back up to 15 seconds of speech. Playback will be repeated until the power is interrupted to load a new message.

CHARLES R. BANKS
Alexandria, VA

Two of my Circuit Cellar projects will do what you want. "Talk to Me!: Add a Voice to Your Computer for $35" (June 1978, page 142) described a pulse-code-modulation technique. This technique is the simplest but the least memory-efficient. It can be used with many digital-to-analog converters.

"Use ADPCM for Highly Intelligible Speech Synthesis" (June 1983, page 35) describes an adaptive differential pulse-code-modulation method. This method, which is more complicated, uses a special chip from Oki Semiconductor for the ADPCM synthesis but uses less memory to store the speech. It takes advantage of the fact that speech contains portions of silence and few rapid changes in signal amplitude.

With PCM, you can get reasonable speech by sampling at 4000 8-bit samples per second, with storage at the rate of 4000 bytes per second. With ADPCM, sampling at the same rate of 4000 bytes per second yields 3 bits per sample, so it uses storage at the rate of 1500 bytes per second. If you needed 15 seconds of speech, these techniques would require 60,000 and 22,500 bytes of memory, respectively.

The sampling rate of either method can be changed to decrease storage requirements but at the expense of fidelity. —Steve

CLOCK INTERFACE

Dear Steve,

I am writing in regard to your response to Lance Walley about the interface of the MM58174A clock chip with the Apple II (January, page 413).

There is an additional subtle problem regarding repeat-interrupt generation using the MM58174A (in an Apple or elsewhere). In order for a series of interrupts to occur, the interrupt must first be properly initialized by reading the interrupt/status register three times (I can count only two reads being necessary from the explanations of what's supposed to be happening, but the data sheet says three). Then the interrupt handler must read the interrupt register of the clock chip, address 15 base 10 or 1111 base 2, three times after each interrupt has occurred. The interrupt output is active low; it stays low until the interrupt register is read.

Thus, in order for a chain of interrupts to occur, CS (pin 1, active low) must be low; DB3 must be high, plus DB2, DB1, or DB0 must be high; pin 2 (READ, active low) must be high; the interrupt-register address must be selected (all four address lines = 1); and pin 3 (WRITE, active low) must be strobed low. With WRITE high, READ must then be strobed low three times to clear and initialize the interrupts.

After each interrupt occurs, the interrupt-register address must be read *three times* in order to clear it and restart the internal interrupt timer. If the interrupt handler fails to clear the interrupt, the result would be the same as described by Mr. Walley: a single pulse. A *single* read of the register would fail to restart the internal counter, and no subsequent interrupts would occur. Similarly, a single initial pulse would also occur if the interrupts were enabled without being cleared.

This all gets somewhat confusing fast. Anyone attempting to interface this chip with anything should get the full National Semiconductor data sheets and study them carefully; they aren't paragons of clarity. They can be found in National Semiconductor's *1984 CMOS Data Book*.

That book also contains information on the MM58274 chip, which has a larger number of interrupt intervals available but is otherwise similar to the MM58174A.

FRANK KUECHMANN
Vancouver, WA

BUILDING OR BUYING

Dear Steve,

Your column has helped inspire me; I'm now pretty sure that I want to build my own computer. I got some basic skills as an electronics technician in the military, but I have been dealing with the software end of things lately.

Would a project of building a computer around the Motorola 68000 be too steep a hill to climb right off the bat? I haven't worked out a complete cost analysis, but I am assuming that building your own computer is cheaper than buying one. Am I right?

MARK JOHNSON
Seattle, WA

I would not suggest building your own computer unless you are interested in using the experience for learning. While it is usually cheaper to build your own, it is hard to beat the likes of a VIC-20 or IBM PC for convenience. All the hardware and software needed is in one small package, and many software programs are available. The cost savings is not large, especially when you consider your time, and it would be hard to build a VIC-20 for less than $80. Troubleshooting the finished computer often requires some expensive test equipment, which should be included in the bottom-line price comparison.

If you want to build one for the experience, use a design based on one of the earlier 8-bit chips (Z80, 6502, or 6800). The newer 16-bit chips certainly have more power, partly due to the many high-level support chips designed to work with them. A design to incorporate these chips and the software necessary to utilize them are best left to professionals. —Steve ■

Over the years I have presented many different projects in BYTE. I know many of you have built them and are making use of them in many ways.

I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, POB 582, Glastonbury, CT 06033, and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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B·Y·T·E·L·I·N·E·S

Conducted by Sol Libes

Mitsubishi Japan has disclosed that it is in the very early stages of developing manufacturing technology needed for production of 4-megabyte IC memory devices. Production is expected in about three to four years. . . . Lotus is reportedly introducing a word processor with an integrated desktop manager that will marry packages recently obtained from an outside source and an acquisition . . . . There are rumors that Microsoft will soon release a BASIC compiler for the Macintosh . . . . NEC is expected to introduce an aggressively priced laser printer to take up the slack in sales of its once popular Spinwriter printer. And they are not alone, as Canon, Epson, and Ricoh are also expected to enter the market with their own products. . . . Look for several companies, including AT&T, to introduce concurrent PC compatibility to their UNIX-based systems at the upcoming November COMDEX show. . . . Now that we have print and file servers on our networking systems, expect the next server to be a modem server. . . . and MicroPro should soon announce a UNIX version of the long-time favorite WordStar word processor. . . . Quantity prices for 64K-bit RAM chips are reportedly 70 cents each and retail street prices are under 80 cents each.

IBM WATCHING

In my July column (page 393) I predicted that IBM would release the PC II this month. It now appears that IBM has pushed back its introduction to the fourth quarter with deliveries to begin in early 1986 so as not to impact current PC sales. Usually, IBM introduces a new product line every three years and makes the previous line obsolete. In the case of the PC, IBM has supported the design for over four years.

The delayed introduction will no doubt give competitors, such as Apple and IBM clone makers, some much-needed breathing room to fill out and establish their product lines. When introduced, the PC II is expected to sell at a price somewhere between the current XT and AT.

IBM has also been showing prototype versions of a laptop computer to selected dealers to get their reactions. These units use 25-line liquid-crystal displays. IBM is rumored to have ceased production of its Portable PC in May. The product never really was a success because most buyers (an estimated 9 to 1) turned to the Compaq when they needed a transportable. Estimates indicate that IBM sold only 50,000 units.

It is interesting to note that several IBM PC-compatibles already have a list price under $1000 (e.g., Tandy, Apricot, and Sanyo). No doubt IBM considered this change in the marketplace when it decided to cease manufacturing the PCjr. There is strong speculation that IBM will soon have another go at the consumer marketplace. However, it must first clear out its huge PCjr inventory. A recent list-price cut from $999 to $725 for the PCjr and a cut from $429 to $399 for the color monitor is expected to stimulate sales. However, this is still a long way from the $900 package price offered last Christmas, which moved a lot of PCjrs and severely cut into sales of the Apple, Commodore, and Atari systems. It is estimated that IBM has sold 240,000 PCjrs (Apple sold over 1.1 million units last year alone).

IBM appears to have caught up with its production backlog of AT systems, just as AT clone makers are beginning to ship their first units. This will no doubt cause some street price cutting. And IBM is rumored to be working on an AT redesign to reduce manufacturing labor cost by as much as 50 percent; this new version is expected to be out in mid-1986.

APPLE

Apple cut more than 1600 employees from its payroll this year, with more cuts expected. At the beginning of the year it had about 6000 employees. Apple also disclosed substantial cuts in advertising, marketing, and new-product development expenditures. For example, Apple withdrew from this year's National Computer Conference after having huge exhibits for several years in a row.

Sales of the Apple II (Apple's traditional bread-and-butter product) are reportedly "sluggish," as are sales of other consumer systems (Commodore recently suffered its first loss ever). In the meantime, sales of the Macintosh are reportedly picking up as more application software becomes available. Sales of the LaserWriter and AppleTalk network are also giving Apple its much-needed penetration in the office marketplace. When coupled with some of the newly introduced page makeup and font-generating software, the Mac is proving quite a success to publishers, newsletter producers, advertising agencies, and commercial art services.

Apple is expected to enhance the Mac with a new keyboard that includes a numeric keypad and trackball cursor control. It has also announced a 20-megabyte hard disk that should start shipping next month. A 40- to 80-megabyte file server for the AppleTalk network is expected toward year's end with speculation that it might contain a parallel port or slots for plug-in boards. Also likely is a new Mac ROM with file-handling software better suited to supporting a hard disk.

Sales of the Macintosh are estimated at 30,000 to 35,000 per month, far below the 80,000 per month capacity of Apple's highly automated production facilities. The Mac is now Apple's chief revenue producer, having passed the Apple II in dollar volume.

There are reports that Apple has already built prototype Macs with 640- by 480-pixel color and 1000- by 800-pixel black-and-white displays. And rumor has it that Apple is experimenting with compact disk and voice input.

In the meantime, Apple IIe owners who have given up on Apple introducing the 16-bit 65816 processor option should check out Micro Magic (Millersville, MD). It is reported to be nearly ready to ship a 65816 add-on board with proprietary operating system capable of addressing up to 16 megabytes of RAM. ■

BYTELINES, *news and speculation about personal computing, is conducted by Sol Libes, the author of numerous books and articles on computers. He is the founder of the* Amateur Computer Group *of New Jersey and a coorganizer of the Trenton Computer Festival. He edits and publishes* Micro/ Systems Journal, *a bimonthly publication for system programmers and integrators. He can be contacted c/o* BYTE, POB 372, *Hancock,* NH 03449.

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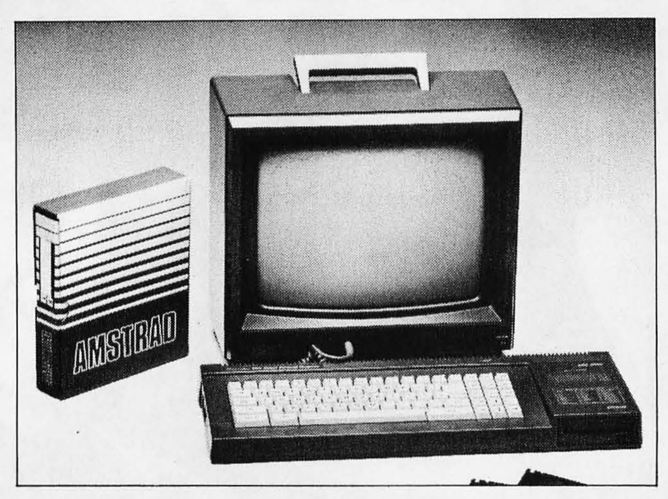
NEW SYSTEMS

The Amstrad CPC6128 PC

Amstrad's CPC6128 is a 128K-byte microcomputer based on Zilog's 4-MHz Z80A microprocessor. It has 48K bytes of read-only memory for BASIC and the operating system. An AY-3-8912 sound-generator chip provides three-voice, eight-octave capability.

The system's standard equipment includes the CP/M and AMSDOS operating systems, the BASIC and Logo languages, a built-in 3-inch disk drive, a color or monochrome monitor, and software. Its 76-key QWERTY-style keyboard has a separate numeric keypad and enlarged enter, shift, caps lock, tab, delete, clear, control, and escape keys. Built-in ports let you add peripherals such as a printer, speech synthesizer, modem, second disk drive, stereo amplifier, joystick, and tape saver. The system comes with three blank 3-inch floppy disks.

The CPC6128 comes in two configurations. The first has a 640- by 200-pixel RGB monitor, one 3-inch floppy-disk drive, and a word processor; it has a suggested retail price of $799. The other model has the same single disk drive, a green monochrome monitor, and WordStar; it costs $699. The manufacturer offers more than 100 applications packages available in the 3-inch-disk format. Contact Amstrad Computers (USA), Indescomp International Inc., Merchandise Mart, Chicago, IL 60654, (312) 295-7100.
Inquiry 615.



Amstrad's CPC6128 *personal computer.*

MicroVAX II

Digital Equipment Corporation's MicroVAX II system is based on the "VAX-on-a-chip" 32-bit MicroVAX 78032. According to the manufacturer, this custom ZMOS VLSI processor has benchmarked performance averaging 90 percent of the VAX-11/780 CPU, depending on application. In most environments, the MicroVAX 78132, which is a matching floating-point chip, provides 85 percent of the VAX-11/780's floating-point performance with a floating-point accelerator.

The MicroVAX II is available in two systems, each of which comes in two configurations. All packaged systems have the console interface and floating-point coprocessor as standard features.

The first MicroVAX II configuration is a single-user, entry-level Ethernet node. It has 2 megabytes of main memory, a 31-megabyte RD52 Winchester hard-disk subsystem, a 400K-byte RX50 dual floppy-disk subsystem, and a DEQNA Ethernet adapter housed in the BA23 pedestal enclosure. The second configuration is a four-user, entry-level, stand-alone system. It also features 2 megabytes of main memory plus a 71-megabyte RD53 hard-disk drive, a 95-megabyte TK50 streaming-tape cartridge drive, a DZQ11 four-line asynchronous multiplexer, and the BA23 pedestal enclosure.

The eight-user department system features 3 megabytes of main memory, the RD53 disk, the RX50 dual floppy-disk drive, the TK50 tape drive, a DHV11 eight-line asynchronous multiplexer, and a BA123 expansion cabinet.

The 16-user, high-end system has 5 megabytes of main memory, three RD53 drives, a TK50 tape drive, two DHV11 eight-line asynchronous multiplexers, and the BA123 expansion cabinet.

Also, a field upgrade kit is available for the MicroVAX I. For $9700, the kit includes a MicroVAX II CPU with 1 megabyte of on-board memory, software, a cabling kit, a disk controller, diagnostics, documentation, installation, and warranty.

DEC offers a choice of software environments for MicroVAX II. You can select MicroVMS, a general-purpose operating system; ULTRIX-32m UNIX software; or VAXELN for dedicated real-time applications. DEC plans to also offer ALL-IN-1, its integrated office and information system for large organizations, and A-to-Z, its integrated business system software for smaller organizations, on the MicroVAX II.

Prices for the MicroVAX II systems range from $18,840 to $43,780, depending on configuration. Contact Digital Equipment Corp., Maynard, MA 01754-2198.
Inquiry 616.

Leading Edge Model D PC

The Model D PC from Leading Edge is an IBM PC-compatible system based on the 8088 processor. Its standard configuration has 256K bytes of memory expandable to 640K bytes on the motherboard, dual 5¼-inch double-sided double-density disk drives, four IBM-compatible I/O slots, parallel and serial ports, a battery-backed clock/calendar, Hercules graphics emulation, and monochrome and RGB monitor output.

The Model D's 83-key keyboard has a numeric keypad and 10 function keys. The 12-inch monochrome monitor comes in green or amber and has an 80-column by 25-line display. An 8087 numeric coprocessor is available as an option.

Leading Edge provides GW-BASIC and MS-DOS with the system. Documentation includes a technical refer-

NEW SYSTEMS

ence manual and an operators guide.

The price for the Model D's basic configuration is $1495. Optional configurations can feature a 14-inch RGB monitor and a combination of a single 5¼-inch floppy-disk drive and a 10-megabyte fixed-disk drive. Contact Leading Edge Products Inc., Systems and Software Division, 225 Turnpike St., Canton, MA 02021, (800) 343-6833; in Massachusetts, (617) 828-8150.
Inquiry 617.

TeleVideo's AT

The TeleVideo AT is an IBM PC AT-compatible that uses Intel's 8-MHz 80286 microprocessor. It comes in two configurations. The entry-level Model I unit includes the system module with 256K bytes of RAM, a keyboard, a 1.2-megabyte floppy-disk drive, an RS-232C serial port, a parallel printer port, a clock/calendar with battery backup, and eight I/O expansion slots. The Model II has the same features as the Model I, but it has 512K bytes of RAM and a formatted 20-megabyte Winchester disk drive.



The TeleVideo AT workstation.

The 14-inch monitor has a nonglare screen. A single graphics controller supports alphanumeric text and graphics. Text resolution consists of a 7- by 9-dot character formed in an 8- by 16-dot cell. The TeleVideo AT supports standard AT-compatible graphics applications written for 640- by 200-pixel resolution as well as those written for enhanced 640- by 400-pixel bit-mapped graphics. The keyboard features a numeric keypad, function keys, and LED-type indicators.

The TeleVideo AT's disk controller has double buffering that eliminates sector interlacing to speed up large disk-file transfers. Transferring a track of data takes only one disk revolution.

MS-DOS 3.1, GW-BASIC 3.1, and the VDISK virtual-disk utility program are available for the TeleVideo AT. Other options are a 20-megabyte tape device, a 360K-byte floppy-disk drive, an 80287 coprocessor, and TeleVideo's Personal Mini network interface boards.

List price for the TeleVideo AT is $3395 for the Model I and $4795 for the Model II. Contact TeleVideo Systems Inc., 550 East Brokaw Rd., POB 6602, San Jose, CA 95150-6602, (408) 971-0255.
Inquiry 618.

PERIPHERALS

Chip Interfaces 80286 Processor with 8088 System

Edsun Labs has developed a CMOS chip that helps interface an 80286 processor to an 8088 system or an IBM Personal Computer bus. Called the EL286-88 Processor Converter, it is a custom VLSI chip that converts 80286 signals and sequences into equivalent signals for the 8088. The company says that to the 80286, the EL286-88 appears as a 16-bit memory or peripheral device operating at the 80286 clock rate; to the 8-bit circuitry, the EL286-88 chip appears as an 8-bit 8088 operating at its own clock rate. The two clocks can operate simultaneously.

When the 80286 requests a 16-bit data transfer from an 8-bit peripheral, the EL286-88 hardware transparently converts the request into multiple 8-bit transfers. The gate array uses about 4000 gates and combines 2- and 3-micron features. The 68-pin leadless-chip-carrier package Edsun uses is the same as that of the 80286. Edsun claims this chip will replace about $60 worth of TTL (transistor-transistor logic) bus-interface chips that would normally occupy 6 square inches of an IBM PC board.

The EL286-88 will reportedly cost from $61 (1 to 99 pieces) to $39 (5000 to 9000). Contact Edsun Labs, 7 Sears Rd., Wayland, MA 01778, (617) 358-5667.
Inquiry 619.

RAM Extension for Macintosh

The DASCH (Disk Acceleration/Storage Control Hardware) memory system stores information electronically on a RAM array rather than mechanically on tape or disk. The manufacturer, Western Automation Laboratories, says this method accelerates the rate of data access, with files like MacPaint being accessed instantaneously.

DASCH plugs into either of the Macintosh's serial

(continued)

ports. The device can share the printer port with an Imagewriter printer, with DASCH intercepting memory commands while enabling printer commands to pass through. DASCH can also attach to the modem port of the Macintosh, allowing device capability for systems networked by AppleTalk and systems with a nonstandard printer. As many as eight DASCH units can be daisy-chained.

Three memory sizes are available: 500K bytes for $495, 1000K bytes for $975, and 2000K bytes for $1785. All units can be factory upgraded to the maximum. Contact Western Automation Laboratories Inc., 1700 North 55th St., Boulder, CO 80302, (800) 227-4637; in Colorado, (303) 449-6400.
Inquiry 620.

Hard-Disk/Tape Subsystem for IBM PCs

Alloy Computer Products offers the microSTOR memory subsystem, which integrates a hard disk and tape backup for the IBM PC, PC AT, PC XT, and compatibles. The 5¼-inch Winchester disk drive has a formatted capacity of 20 megabytes, while the file-oriented, streaming-tape unit has a formatted capacity of 23 megabytes per microcartridge.

The microSTOR is an external unit measuring 16 by 8 by 5 inches, and it requires just one controller card for use of both hard disk and tape drive. Packaged with the subsystem, the microTIP software permits complete file-oriented backup and restoration of data. The hard disk uses 11-bit error-correcting code.

The microSTOR retails for $2995. Contact Alloy Computer Products Inc., 100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100.
Inquiry 621.

700-cps Serial Printer

Output Technology's OT-700 printer produces 700 characters per second in single-pass and 350 cps in dual-pass printing. The device incorporates three print heads to achieve these rates. The OT-700 offers both serial and parallel ports coupled with a 4000-character data buffer.

Dot-addressable graphics printing is available in two operating modes: 50 by 69 dots per inch for high-speed output and 100 by 69 dpi for higher resolution. Menu-driven commands let you configure the machine.

For software compatibility, the OT-700 responds to a modified set of Epson command codes. The printer costs $1795. Contact Output Technology Corp., East 9922 Montgomery, Bay #33, Spokane, WA 99206, (509) 926-3855.
Inquiry 622.

Compact Laser Printer

Konica's LP-3010 laser printer produces 10 pages per minute with a resolution of 300 by 300 dots per inch. Among its features are a rotation function, character elongation and condensation, superscript and subscript, reverse characters, and underline.

Interfaces include video, optional print controller (equipped with a form character), and RS-232C and Centronics parallel ports.

The compact printer weighs 30 kilograms and measures 415 by 530 by 220 millimeters. Without the print controller, the LP-3010 costs $2500. Contact Konica/TMC Co., POB 423, Wayne, PA 19087, (215) 964-8862.
Inquiry 623.

Low-Cost Seven-Port Multiplexer

Complexx Systems' TX7 point-to-point statistical multiplexer compresses data from up to seven devices onto one phone line, replacing multiple phone lines and modems. All seven devices may communicate simultaneously at speeds up to 9600 bps.

The TX7 automatically corrects any errors caused by noise in the transmission line. Using its 32K bytes of internal buffer, the multiplexer also allows devices operating at different speeds and setup parameters to communicate. RAM-stored menus enable each user port to be individually programmed.

The TX7 costs $1495. Contact Complexx Systems Inc., 4930 Research Dr., Huntsville, AL 35805, (205) 830-4310.
Inquiry 624.

Graphics Display for DEC, Hazeltine Terminals

Series 1500 Graphics Display Terminals provide a Tektronix 4010/4014 graphics display for such terminals as the DEC VT-102 and the Hazeltine 1500.

The series offers a 1024- by 800-pixel display (with a 1024 by 1024 physical memory area). The 14-inch screen features amber or green display with 24 rows by 80 or 132 columns. You may select four scrolling speeds. Other features include data-transmission rate of 38,400 bits per second, 32 programmable function keys, built-in printer port, and tilt-and-swivel motion.

The Model 1575 lists for $2395 and is compatible with the VT-102; the Model 1550 lists for $2295 and is compatible with ADM, TVI, ADDS, and Hazeltine terminals. Contact Cleveland Codonics Inc., 18001 Englewood Dr., Cleveland, OH 44130, (216) 243-1198.
Inquiry 625.

Monochrome Monitors for IBM PCs

NEC's two monochrome monitors, the green JB-1280DA and the amber JB-1285DA, are TTL plug-compatible with the IBM PC and PC work-alikes. Both monitors are priced at $199.

The 12-inch screens feature an active display area of 210 millimeters wide by 150 millimeters high. Video bandwidth is 20 MHz, providing a resolution of 720 dots horizontal by 350 lines vertical.

Both monitors require the PC to have a monochrome display/printer adapter card. The connecting cable is built into the monitors. Contact NEC Home Electronics Inc., Suite 10, 700 Nicholas Blvd., Elk Grove Village, IL 60007, (312) 228-5900.
Inquiry 626.

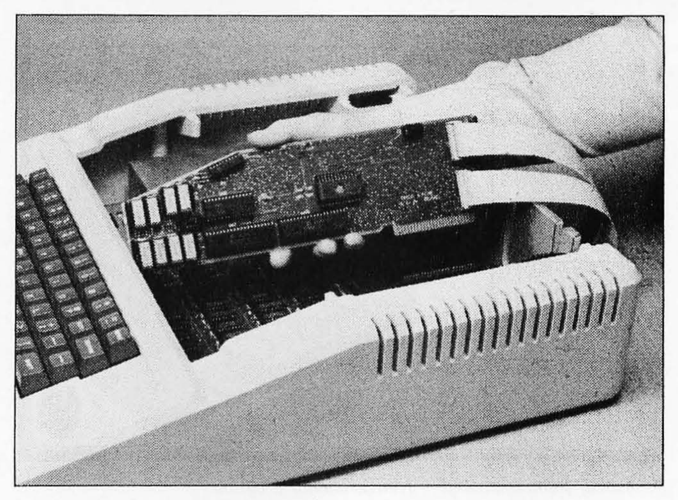
ADD-INS

Kache Board for the Apple

Ohio Kache Systems' Kache Board is an SCSI hard-disk interface with a cache host adapter. It can reside in slots 4 through 7 of the Apple II+ or IIe and holds up to one-quarter megabyte of hard-disk data. This buffer memory reduces the apparent hard-disk access time.

The Kache Board has a Z80 microprocessor that manages the cache buffers' operation without drawing on the Apple's 6502 main processor. The data most frequently accessed is maintained in these buffers, while the contents of infrequently accessed buffers are rotated to hold new data. The manufacturer uses SMD (surface-mounted devices) technology to combine the necessary circuitry on a single board.

The Kache Board sells for $695. Contact Ohio Kache Systems Corp., 75 Tahlequah Trail, Springboro, OH 45066, (800) 338-0050; in Ohio, (513) 746-9160.
Inquiry **627.**


Ohio Kache Systems' Kache Board.

MAS 2122 Two-Chip Modem

The MAS 2122 modem from Micronas is an integrated two-chip product that operates in two modes. In basic mode, it functions as a stand-alone modem with the standard CCITT interface circuits. In extended mode, its two chips operate under the control of a microprocessor. The circuitry allows for serial or parallel I/O interface.

This product provides CCITT V.22 A, B, and V.21 and Bell 212A, 103, and 113 modem capability. It also gives you dual-tone multifrequency generation, call-progress tone detection, internal UART, and timing sequences for automatic handshaking. With these features, the MAS 2122 can dial, monitor calls, create asynchronous data, and provide worldwide modem capability.

The MAS 2122's design consists of two ICs: the MAS 7246 and the MAS 7247. The MAS 7246 includes all the circuitry required for a microprocessor or RS-232C interface, a UART, 300- and 1200-bps modulators and demodulators, a scrambler and descrambler, and complete timing and logic for generating and answering the modem handshake. It also has six internal control and status registers that provide access to signals on both ICs in the microprocessor configuration.

The MAS 7247 contains the filters, line equalizers, transmitter amplifier, DTMF pilot tone generator, call-progress tone detector, digital AGC, carrier detector, and system clock. If you need a different equalization network, the MAS 7247 allows for adding an alternative network.

The two-chip, 1000-piece price for the MAS 2122 is $65 to $75 depending on the interface. Contact Micronas Inc., P.O. Box 42, SF-00441 Helsinki, Finland; tel: 562 3300; Telex: 8100691.
Inquiry **628.**

UNIX/MMU for Stride 400 Series

Stride Micro offers UNIX System V and a memory-management unit (MMU) for its 400 Series of microcomputers. UNIX System V for the Stride runs with no wait states at 10 MHz on the 68000 while using active memory management. It applies up to 2 megabytes of RAM on the main CPU board. An optional 10 megabytes of RAM adds a single wait state. The MMU option plugs into the 68000 microprocessor socket.

UNIX is shipped on a 45-megabyte ¼-inch streaming-tape cartridge. The UNIX package includes four compilers (C, FORTRAN 77, SNO, and BS) and all the standard development tools. An EMACS editor is available separately. The system supports all the Stride hardware options, such as tape backup, floating point arithmetic, and local-area networking.

Suggested retail price for UNIX is $1175; you can also order it on disk for an additional charge. The MMU hardware option is $500. Contact Stride Micro, 4905 Energy Way, Reno, NV 89502, (702) 322-6868.
Inquiry **629.**

Micro Speech Lab

Software Research's Micro Speech Lab consists of a printed circuit board, software, a microphone, a headphone set, and a users manual. To use this speech- and signal-analysis system, you need an IBM PC or compatible with a minimum of 192K bytes of RAM, PC-DOS, and an IBM color/graphics card.

The package has five major modules: signal input, waveform display, audio output, analysis, and file management. You use function keys to manipulate the program.

Micro Speech Lab's suggested retail price is $1350 ($1800 Canadian). Contact Software Research Corp., 3939 Quadra St., Victoria, British Columbia V8X 1J5, Canada, (604) 727-3744.
Inquiry **630.**

(continued)

SOFTWARE • APPLE

BASIC-to-Pascal Translator

Woodchuck Industries has developed a language translator that converts Applesoft BASIC programs to Apple Pascal. P-tral reads the BASIC source program from disk and generates the equivalent Pascal source code. The disk-based package is capable of translating commercial applications and has no restrictions on the size of programs it will convert.

P-tral breaks the BASIC program into its parts and analyzes actions, formulas, and instruction sequences before translation rules build up Pascal code. Syntax errors are pinpointed during conversion; you can either continue or abort. You can make corrections to the BASIC program using a Pascal editor and don't have to return to the BASIC system.

Requirements are an Apple II+, IIe, or IIc with at least 64K bytes of memory, two drives, an 80-column card, Apple DOS 3.3, and Apple Pascal 1.1 or 1.2. P-tral sells for $125; an upgrade is slated for the fall and will reportedly sell for $250 (or for $25 to owners of version 1). Contact Woodchuck Industries Inc., 340 West 17th St. #2B, New York, NY 10011, (212) 924-0576.

Inquiry 631.

Circuit-Design Package Runs on the Mac

You can design and test computer circuitry on the Macintosh with a program called LogiMac. The interactive software presents a "live" circuit on the screen; the circuit responds immediately to connection, input, and device-parameter changes. You have complete control over device delay, clock speed, timing display resolution, and other parameters.

LogiMac lets you catch design errors before they are wired into the real hardware by simulating circuit operation. Circuit output can be displayed on simulated devices or in the form of a timing diagram that graphs signal changes over time. The diagram is updated continuously to reflect design and input alterations. The program uses five signal states to correctly simulate circuits with design errors such as unconnected inputs or conflicting outputs.

Maximum drawing size is 38 by 38 feet; it is limited only by available memory. Circuit or timing diagrams may be passed to MacPaint in one-page segments for printing, enhancement, or incorporation in other documents.

LogiMac is priced at $59.95 for single use; an institutional license allows up to 20 copies and costs $200. For more information, contact Capilano Computing Systems Ltd., POB 86971, North Vancouver, British Columbia V7L 4P6, Canada, (604) 669-6343.

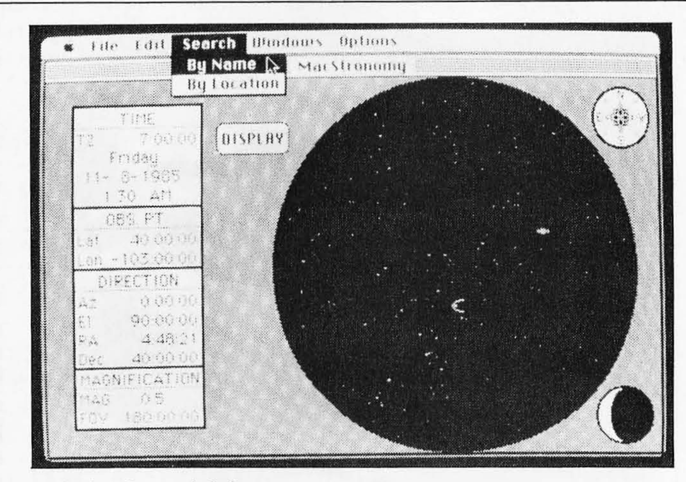
Inquiry 632.

Bulletin Board for Apple IIs

The Universal Bulletin Board runs on Apple IIs and features up to 10 message bases, uploading and downloading, on-line games, variable system access, electronic mail, a text editor, and report capabilities. The package is designed to operate as a remote-access message system suitable for business and personal use. A password function allows either public or private access at the discretion of the sysop.

The bulletin-board software sells for $149.95. Developed by Universal Computers (Highland Park, Illinois), the program is distributed by the Association of Independent Microdealers, 3010 North Sterling Ave., Peoria, IL 61604, (309) 685-4843.

Inquiry 633.



A display from Alphabyte's MacStronomy program.

Map the Stars with Mac

An astronomy program for the Macintosh, MacStronomy maps the stars, moon, and planets in their proper locations for any given date and time. You can select the region of the sky you want mapped by setting the location on the earth from which the "observation" is to be made, the date and time, the direction of the observation, and the field of view diameter.

You can set the direction in one of two ways: azimuth and elevation relative to the point from which you're observing or right ascension and declination relative to the stars. Thus you can use MacStronomy to determine in what direction to look for objects in the sky at a specific time or location or to determine what objects will be visible. MacStronomy can also display the location of Halley's comet for any time you choose; an alternate map shows the comet's orientation around the sun.

Using the mouse, you can point to any celestial object on the sky map. The program will display the coordinates of the star or planet, its name, and a brief description. The astronomical information provided with the program is also supplied in text form; MacStronomy has a translator to convert the text into an internal form used by the program, which lets you edit the database to add stars, planets, and galaxies.

MacStronomy lists for $90. Contact Alphabyte Software, POB 649, Lafayette, CO 80026, (303) 665-3444.

Inquiry 634.

SOFTWARE • IBM PC

TopView Tools

Lattice has released a set of tools for developers who write applications that employ IBM's TopView window environment. The TopView Toolbasket is a library of more than 70 C functions you can use to control window, cursor, and pointer operations. Other functions handle debugging and cut-and-paste operations. The Toolbasket also contains sample source programs you can use as models.

Developed for Lattice by Strawberry Software, TopView Toolbasket runs on the IBM PC, PC XT, PC AT, and compatibles with at least 256K bytes of RAM (512K bytes is recommended). The price is $250; source code costs $250 more. For additional information, contact Lattice Inc., POB 3072, Glen Ellyn, IL 60138, (312) 858-7950.

Inquiry **635.**

Mapping Package

GMX-3300 is a mapping package designed to assist geologists and engineers in exploration, resource analysis, mine planning, and civil-engineering applications. Based on Magnum's GeoMetriX for mainframes, the program features grid value interpolation and manipulation, area and volume calculation, boundary definition, and line and point data input.

You can use the program to generate trend surfaces (polynomial and trigonometric) for analysis of data tendencies. Contour, resource, and slope maps (with boundary clipping) can be produced on the graphics screen or with a pen plotter. Interfaces are available for Summagraphics digitizers as well as Amdek and Houston Instrument plotters; other interfaces are available upon request.

GMX-3300 runs on the IBM PC and compatibles using MS-DOS, PC-DOS, or UNIX. It also requires a high-resolution graphics board, 512K-byte memory, and 10-megabyte hard disk. Software alone costs $3300, or you can buy it bundled with a NEC APC III, digitizer tablet, and six-pen plotter for $9990. Contact Magnum Computer Systems Inc., POB 620038, Littleton, CO 80162, (303) 973-4407.

Inquiry **636.**

Signal Processing on the PC

ILS-PC 2 is an integrated program for data display and manipulation, digital filtering, and advanced signal processing on the PC, PC XT, and PC AT. You can use the package for computing and storing fast Fourier transforms and Hilbert transforms, estimating spectral densities and transfer functions, performing auto- or cross-correlation on time-series data, and convolving time series and filter impulse responses.

ILS-PC 1, which you need to run the signal-processing package, is a set of analysis programs for data acquisition and manipulation, waveform display and editing, spectral display, statistical computation, and digital filtering.

Both ILS programs require 256K bytes of memory and a graphics board on a PC running DOS 2.1. In order to get the programs running at minicomputer speeds, the vendor states that you'll need a math coprocessor. The license fee for ILS-PC 1 is $995; for ILS-PC 2, it's $1495. Contact Signal Technology Inc., 5951 Encina Rd., Goleta, CA 93117, (805) 683-3771.

Inquiry **637.**

A Bridge to Macintosh Office

Tangent Technologies' IBMacBridge enables IBM PCs and compatibles to tap into the Apple Macintosh Office. The IBMacBridge card slips into a PC expansion slot and lets you directly access Apple products, including the LaserWriter, through the AppleTalk network. The package includes software that converts text created with PC word processors (WordStar, for example) into PostScript files.

In addition to printing text and graphics on the LaserWriter, you can use a PC to transfer files with Macs, act as a file server for the Macintosh Office, access other servers on AppleTalk, and serve as a gateway to other networks.

IBMacBridge has a suggested retail price of $595. For more information, contact Tangent Technologies, Suite 100, 5720 Peachtree Parkway, Norcross, GA 30092, (404) 662-0366.

Inquiry **638.**

Pascal for 8086 Family

Professional Pascal is a resident and cross compiler that runs under MS-DOS on all the processors in Intel's 8086 family. It can generate code for any of the processors, including the instructions special to the 80186 and 80286. A VAX resident compiler is also available.

The Professional Pascal compiler produces the optimized code. Among the optimizations are common subexpression elimination, retention and reuse of register contents, short-circuit evaluation of Boolean expressions, and constant folding. The compiler supports five memory models: small, compact, medium big, large, and ROMable. Using the Microtec Linker or other Intel-compatible linker, you can specify areas of RAM or ROM for any code section.

Microtec's package supports more than 200 distinct error and warning diagnostics. Run-time library routines and utilities include string and heap operations, a portable I/O library, access to the command line and environment variable, and system interfaces. Extensions provide machine-dependent operators, varying-length strings (up to 64K bytes), three precisions of integer and floating arithmetic, and IEEE floating-point math.

A single license with one-year warranty costs $895. Professional Pascal requires 225K bytes of main memory for operation and at least 1.2 megabytes of hard-disk memory for installation. For more information, contact Microtec Research Inc., POB 60337, Sunnyvale, CA 94088, (408) 733-2919.

Inquiry **639.**

(continued)

SOFTWARE • OTHER COMPUTERS

Programming Environment with AI Module

Superforth 64 + AI, an integrated package for the Commodore 64, is a programming environment that includes an artificial-intelligence module and advanced math capabilities. The package is designed to help you develop expert systems.

At Superforth's core is a programming language that lets you define your own English-like "word" functions. These words are stacked to create rules; an interpreter then applies the rules to make decisions. Antecedent and consequent reasoning are possible.

The program incorporates the utilities needed to write applications, including full control of color graphics; sound, music, and sprite editors; trace and decompiler facilities; and virtual memory. Superforth 64 + AI sells for $99. For more information, contact Parsec Research, Drawer 1766, Fremont, CA 94538, (415) 651-3160.

Inquiry **640.**

Four for Color Computer

Computerware has released four programs for the TRS-80 Color Computer.

The OS-9 Macro Conditional Assembler, or Mac, produces OS-9 modules and supports standard 6809 assembler mnemonics and directives. It can handle conditional assembly, repeat sequences, and inclusion of source library files. All Mac source files are compatible with those produced by the Microware assembler. Mac requires OS-9 and 64K bytes of memory. It costs $49.95.

The OS-9 Text Formatter interfaces with any editor that produces standard ASCII text files. It's also NROFF-compatible. Among its features are centering, page numbering, and dynamic dates. The formatter requires 64K bytes of RAM and OS-9 and costs $34.95.

For development under OS-9, Computerware offers CBUG, a screen-oriented debugger with a disassembler, single-step capabilities, memory window, and access to the OS-9 shell. It also has a built-in hexadecimal calculator. CBUG, which sells for $39.95, requires 64K bytes of RAM and OS-9.

Color Connection III is a communications package that works with Hayes and Radio Shack modems. It incorporates CompuServe's Protocol B, XMODEM protocols that download directly to and from disk, and an automatic XON/XOFF protocol that downloads directly to disk. The price is $49.95. At least 32K bytes of RAM is necessary.

When you order any of these packages, add $2 to the cost for shipping. Contact Computerware, POB 668, Encinitas, CA 92024, (619) 436-3512.

Inquiry **641.**

Atari EEPROM/EPROM Programmer

Designed to convert an Atari into a development tool, the Proburner can be used to program EPROM types 2716 through 27128 (plus the 2532) and a variety of 2K-byte through 8K-byte EEPROMS. The cartridge plugs into the slot of the Atari 400/800 and XL/XE series.

Among the functions the Proburner provides are copy, erase check, verify, and burn in. Binary files can be stored or loaded to disk or cassette. You can call a monitor for memory display and changes, block moves, and printer dumps. The unit can also run chips from its socket. Because Proburner offers electronic configuration for each EPROM type, you don't need adapters or switches.

Proburner costs $149. Contact Thompson Electronics Ltd., Suite 502, 7 Jackes Ave., Toronto, Ontario M4T 1E3, Canada, (416) 960-1089.

Inquiry **642.**

Widen Your Screen

You can enlarge the 40-column LCD screens of the Tandy Model 100 and the NEC PC-8201 with T-View 80. The software transforms a 40-column screen into a movable 60-column window on an 80-column display.

T-View 80 can use the machines' text-processor and telecommunications programs. You can adjust word wrapping to any width up to 80 columns. The package has a suggested retail price of $39.95 and comes with a utility that keeps track of file sizes and manages memory. It's available at Radio Shack stores or from Traveling Software Inc., 11050 Fifth Ave. NE, Seattle, WA 98125, (206) 367-8090.

Inquiry **643.**

Improvising Commodore

Cantus, a music program for the Commodore 64, improvises its own tunes based on your input. Instead of typing notes, you enter choices for tempo, harmony, rhythm, counterpoint, voice range, and tone color. Cantus uses these selections to create, in real time, its three-voice improvisations.

Each set of choices becomes a patch. The software comes with more than 65 patches representing a variety of musical styles. You can modify and store any patch while Cantus is performing. A graphic display shows the notes as they play.

Cantus was created by Michael Riesman, a composer and performer who has worked as musical director of the Philip Glass Ensemble.

No musical knowledge is required to operate the program, but you do need a Commodore and $54 (plus $2 shipping). Contact Algo-Rhythm Software, 176 Mineola Blvd., Mineola, NY 11501, (800) 645-4441; in New York, (516) 294-7590.

Inquiry **644.**

WHERE DO NEW PRODUCT ITEMS COME FROM?

The new products listed in this section of BYTE *are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to* New Products Editor, BYTE, *425 Battery St., San Francisco, CA 94111.*

What the world really needs is a 99 cent Double Sided, Double Density Diskette with a LIFETIME WARRANTY!

And DISK WORLD! has it.

Introducing Super Star Diskettes: the high quality diskette with the lowest price and the best LIFETIME WARRANTY!

In the course of selling more than a million diskettes every month, we've learned something: higher prices don't necessarily mean higher quality.

In fact, we've found that a good diskette manufacturer simply manufactures a good diskette...no matter what they charge for it. (By way of example, consider that none of the brands that we carry has a return rate of greater than 1/1,000th of 1 percent!)

In other words, when people buy a more expensive diskette, they aren't necessarily buying higher quality.

The extra money might be going toward flashier advertising, snazzier packaging or simply higher profits.

But the extra money in a higher price isn't buying better quality.

All of the good manufacturers put out a good diskette. Period.

How to cut diskette prices ...without cutting quality.

Now this discovery posed a dilemma: how to cut the price of diskettes without lowering the quality.

There are about 85 companies claiming to be "diskette" *manufacturers*.

Trouble is, most of them aren't manufacturers.

Rather they are fabricators or marketers, taking other company's components, possibly doing one or more steps of the processing themselves and pasting their labels on the finished product.

The new Eastman Kodak diskettes, for example, are one of these. So are IBM 5¼" diskettes. Same for DYSAN, Polaroid and many, many other familiar diskette brand names. Each of these diskettes is manufactured in whole or in part by another company!

So, we decided to act just like the big guys. That's how we would cut diskette prices...without lowering the quality.

We would go out and find smaller companies to manufacture a diskette to our specifications...specifications which are higher than most...and simply create our own "name brand" diskette.

Name brand diskettes that offered high quality at low prices.

SUPER STAR DISKETTES ★

5¼"	5¼"
SSDD	**DSDD**
.91 ea.	**.99 ea.**
Qty. 50	Qty. 50

Super Star diskettes are sold in multiples of 50 only. Diskettes are shipped with white Tyvec sleeves, reinforced hubs, user ID labels and write-protect tabs.

Boy, did we get lucky. Our Super Star Diskettes are the same ones you've been using for years...without knowing it.

In our search for the low priced, high quality diskette of our dreams, we found something even more interesting.

We found that there are several manufacturers who don't give a hoot about the consumer market for their diskettes. They don't spend millions of dollars in advertising trying to get you, the computer user, to use their diskettes.

Instead, they concentrate their efforts on turning out the highest quality diskettes they can...because they sell them to the software publishers, computer manufacturers and other folks who (in turn) put their name on them...and sell them for much higher prices to you!

After all, when a software publisher or computer manufacturer or diskette marketer puts their name on a diskette, they want it to work time after time, everytime. (Especially software publishers who have the nasty habit of copy-protecting their originals!)

Super Star Diskettes. You already know how good they are. Now you can buy them...cheap.

Well, that's the story.

Super Star diskettes don't roll off the boat from Pago-Pago or emerge from a basement plant just east of Nowhere.

Super Star diskettes have been around for years...and you've used them for years as copy-protected software originals, unprotected originals. Sometimes, depending on which computer you own, the system master may have been on a Super Star diskette. And maybe more than once, you've bought a box or two or more of Super Star diskettes without knowing it. They just had some "big" company's name on them.

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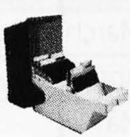
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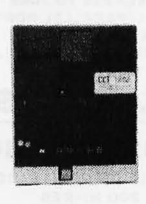
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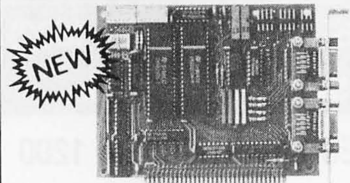
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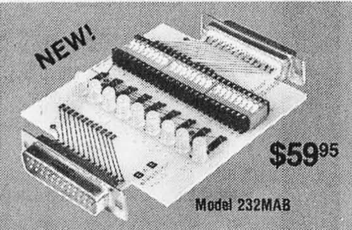
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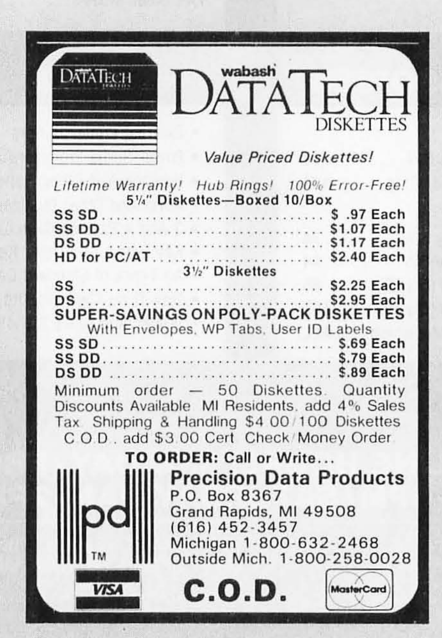
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Introducing Wabash Pinnacle Series Diskettes.

Two years ago, if you'd told me I'd be writing this ad, I would have laughed.

At that time, Wabash diskettes were synonymous with "s—t".

Just saying that quality control was poor would be charitable.

So much was wrong that DISK WORLD wouldn't sell them.

That was yesterday.

Kearney-National Inc., a $202-million division of a much larger company, came into Wabash.

Out went the old management, the old methods, the old production techniques...and in went a lot of new people, ideas, production lines and some really imaginative thinking.

The end result.

Today, I'm proud to offer you the Wabash Pinnacle Series of diskettes at the prices shown.

This isn't evolution in diskette manufacturing: it's revolution.

Here's what you get.

Wabash Pinnacle diskettes are
...certified 100% Error Free
...are coverd by a LIFETIME WARRANTY
...meet or exceed all industry specifications (by quite some distance)
...and are simply the best value in diskettes available today.

The torture test.

Considering Wabash's earlier dubious reputation, I wasn't exactly a true believer when their Director of Marketing came *into my office* with samples.

So I took a box at random, selected a disk, bent the thing every which way and slipped it into my IBM-PC.

It formatted. It booted. It stored and retrieved data.

That wasn't enough.

I gave samples of the diskettes to Curt Rostenbach and, in turn, to Tom Streit, both hackers of long experience and members of the Waukegan (Illinois) Apple Users Group.

Tom really went at it.

He took a quartz-halogen lamp, aimed it at the diskette until it started to smoke (and melt)...and then formatted, booted the diskette and stored and retrieved data!

The same terribly (and intentionally) mutilated diskette ran on an ITT, Corona and IBM.

Curt was nicer.

He simply bent the diskette every which way...and it still formatted, booted and ran on his Apple.

The best buy I've ever seen.

DISK WORLD!, Inc. sells more flexible magnetic media by mail-order than anyone else in the world.

I, as President of the corporation, won't tolerate a product with a failure rate of more than 1/1000th of 1 percent.

I also don't like companies who try to milk a "quality" or "premium" image for a higher price like Dysan and Verbatim did...until they failed.

As President of DISK WORLD!, Inc., my motto is simple: "the best diskette for the least amount of money."

Wabash is it.

Right now, there is no better value than the Wabash Pinnacle Series of diskettes.

Granted, you have to buy a hundred at a time, but so what? Split the order with friends, relatives, co-workers or even your worst enemies.

The key thing is to get the most diskette for the money.

And this is it.

(Incidentally, as a corporation, we put our money where our mouth is. Our first order for Wabash Pinnacle Diskettes was 1.5-million units.)

Pinnacle Series
10 DISKETTES
Single Side, Double Density
100% Error Free

That's an awful lot of faith and confidence.

But, then again, I have the diskette that Tom Streit literally melted...and kept on running.

The truth about $1.00 or less diskettes.

More and more ads are popping up offering diskettes for $1.00 or less.

By the same token, more and more people who were selling used cars a few months ago are now selling diskettes by mail.

We did a little survey of current ads for diskettes advertised for a dollar or less and did some analysis of the market and here's what we found as it applies to 5.25″ DSDD diskettes "supposedly" selling for a dollar or less.

VENDOR:	ADVERTISED LOW PRICE:	ACTUAL PRICE PER 100:	ACTUAL MFGR.:
Unitech	.89 ea.	.92 ea.	Unspecified.
Datatech	.99 ea.	.99 ea.	Unspecified.
Computer Club	.95 ea.	.98 ea.	Unspecified.
	.99 ea.	1.02 ea.	Unspecified.
Communications & Electronics	.49 ea.	.80 ea.	Unspecified.
Precision Data	.89 ea.	.93 ea.	Unspecified.
Diskette Connec.	.93 ea.	.93 ea.	Unspecified.
Comp Soft Serv.	.77 ea.	.77 ea. + shpg.	Unspecified.
Computer/Computer	.99 ea.	.99 ea.	Unspecified.
DISK WORLD	.89 ea.	.92 ea.	Wabash Datatech

The real truth about $1.00 or less diskettes.

It costs all diskette manufacturers about the same to produce a diskette. Some may charge more because they want to project a "premium quality" image, ala the late, lamented Dysan who bought their basic media from 3M.

Some charge less because they sell a sub-standard product...and we're not foolish enough to name names here.

But here's the truth about the $1.00 or less diskette market.

It falls into four categories:

1. The DISK WORLD's of the universe who simply are so big that they can buy first quality product in massive quantities and choose to pass on the savings to you. (Precision Data and Diskette Connection on **BRAND NAME** products also fall into this category.)

2. The people who buy "cosmos"...stuff from major manufacturers that usually hits quality control standards, but is cosmetically blemished and thus can't be packaged and sold under the manufacturer's own name.

3. "Duplicator Quality". Uncertified media, usually below manufacturer's own standards and frequently below ANSI and IBM standards. Sold on an "as-is" basis with the understanding that the manufacturer's name will never be divulged. Usually about a 20% reject rate...as compared to DISK WORLD's standard of less than 1/1000th of 1% reject/return rate. Next to garbage, this is the source of most diskettes advertised at a dollar or less.

They may work...and then again they may not. (Frankly, the odds at the Blackjack table in Las Vegas are more in your favor.)

4. Garbage. Stuff that shouldn't be sold at all. But some manufacturers are hurting for cash, so they sell it anyway. (After all, they want to meet their payroll. Look what happens when you don't: you become a Dysan or Verbatim. Lots of history, but no money.) More and more garbage is being dumped into the market as manufacturers become pressed for cash and are motivated into selling anything and everything they can manufacture. (Read the article in FORBES about Verbatim and its "Bonus" brand.)

Finally, the Taiwanese counterfeiters are moving into the act. Perfect duplicates of the packaging of major manufacturers with one exception: the quality isn't there.

The Critical Factor.

Only DISK WORLD!, Inc. offers fully brand-identified, LIFETIME-WARRANTY product for less than a dollar.

Every one else offering 5.25″ product for less than a buck doesn't tell you who makes it.

We do.

And that ought to tell you a lot right there.

Ordering & Shipping Instructions

SHIPPING: Wabash Pinnacle Diskettes are sold in multiples of 100 only. Shipping charges are $3.00 per 100, regardless of type or size.

PAYMENT: VISA, MASTERCARD and PREPAID orders accepted. Corporations rated 3A2 or better and government and quasi-government open accounts are accepted on a NET 15 basis.

C.O.D. orders are subject to a $5.00 special handling charge. (Sorry for the increase, but too many people have been refusing C.O.D. orders or using bad checks. It's a classic example of a few "bad eggs" making life more expensive for everyone else.)

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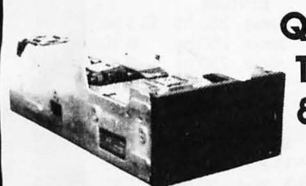
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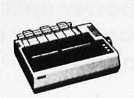
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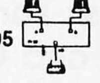


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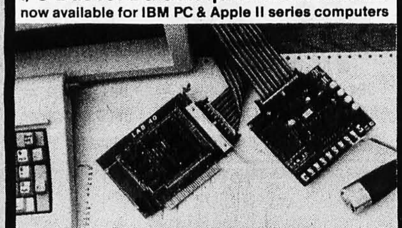
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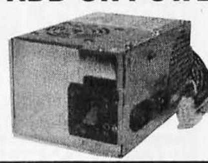
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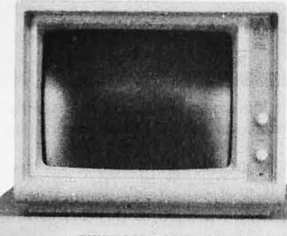
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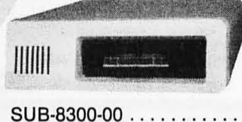
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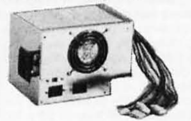
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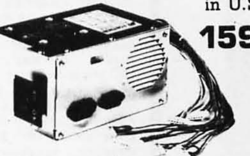


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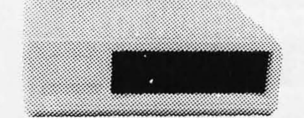
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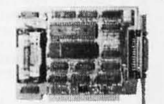
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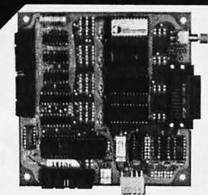
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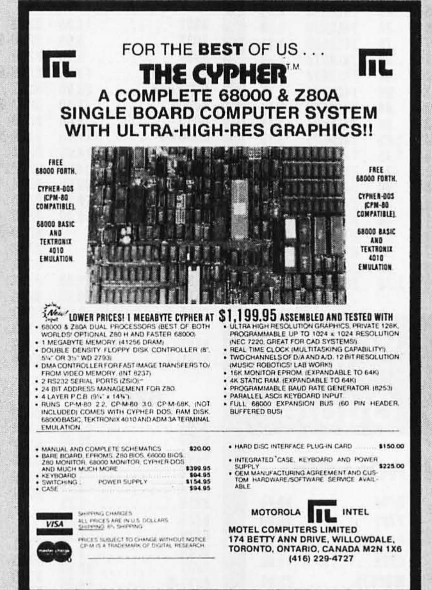
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74LSXX	.25	74ALSXX	.35
74LS1XX	.35	74ALS1XX	.45
74LS2XX	.50	74ALS2XX	.60
74LS3XX	.50	74ALS3XX	.60
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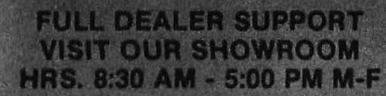
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8" DSDD Soft Sector (Unformated)	—	—	F14A-Z	2.09	—	—	3102-Z	2.59
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5¼" SSSD Soft Sector w/Hub Ring	6431-Z	0.74	M11A-Z	0.89	—	—	—	—
5¼" SSSD Same as above but bulk product	6437-Z	0.54	M11AB-Z	0.79	—	—	—	—
5¼" SSSD 10 Hard Sector w/Hub Ring	—	—	M41A-Z	0.89	—	—	—	—
5¼" SSDD Soft Sector w/Hub Ring	6481-Z	0.84	M13A-Z	0.99	54974-Z	1.24	3481-Z	1.24
5¼" SSDD Same as above, but bulk product	6487-Z	0.64	M13AB-Z	0.89	—	—	—	—
5¼" SSDD 10 Hard Sector w/Hub Ring	—	—	M43A-Z	0.99	—	—	—	—
5¼" DSDD Soft Sector w/Hub Ring	6491-Z	0.94	M14A-Z	1.09	54980-Z	1.44	3491-Z	1.69
5¼" DSDD Same as above, but bulk product	6497-Z	0.74	M14AB-Z	0.99	—	—	—	—
5¼" DSDD 10 Hard Sector w/Hub Ring	—	—	M44A-Z	1.09	—	—	—	—
5¼" DSDD 16 Hard Sector w/Hub Ring	—	—	M54A-Z	1.09	—	—	—	—
5¼" DSDD Soft Sector 96 Tracks per inch	6501-Z	1.49	M16A-Z	2.49	—	—	3501-Z	2.49
5¼" DS High Density Soft Sector for IBM PC AT	—	—	M1BA-Z	3.99	—	—	5500-Z	3.99
3½" SSDD Soft Sector micro-floppy	—	—	C13A-Z	2.74	54112-Z	2.99	6100-Z	2.49



Super Disk	Wabash	BASF	Memorex
Lifetime warranty	Lifetime warranty	Lifetime warranty	Lifetime warranty
For more info on Super Disk call	For more info on Wabash call	For more info on BASF call	For more info on Memorex call
800-USA-DISK	**800-323-9868**	**800-343-4600**	**800-448-1422**
In Michigan 313-973-1111	In Illinois 312-593-6363	In Massachusetts 617-271-4000	Monday-Friday 9am-4pm ET

Inquiry 60

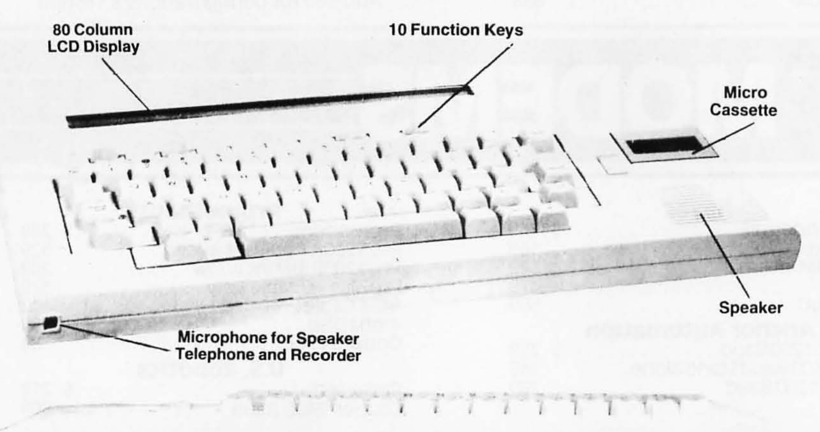
California Digital

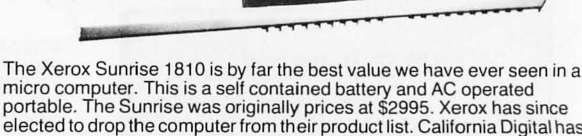
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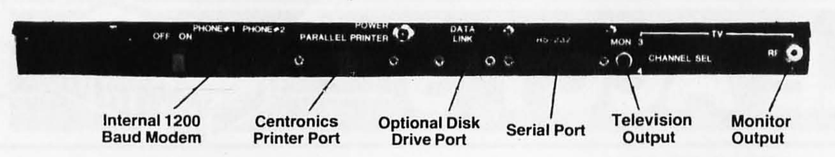
XEROX $299

SUNRISE COMPUTER

$2995







The Xerox Sunrise 1810 is by far the best value we have ever seen in a micro computer. This is a self contained battery and AC operated portable. The Sunrise was originally prices at $2995. Xerox has since elected to drop the computer from their product list. California Digital has purchased all the remaining inventory and is making the unit *available at* a fraction of its original cost.

This portable features a built in 80 column liquid crystal display, along with both RF monitor and television outputs. The internal 300/1200 baud modem includes an auto dial telephone assembly. The units has both centronics parallel and a serial port programmable to 19,200 baud.

The self contained micro cassette is capable of capturing data from the keyboard as well as doubling as an recorder for dictating messages.

An optional dual floppy disk drive module, pictured above, is available for only $219. (when purchased with the Sunrise 1810). Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any CP/M program in Xerox 5¼" disk format and over 5000 CP/M programs available in public domain.

PRINTERS

MATRIX PRINTERS

Star Gemini-10X 120 char/sec.	STR-G10X	249.00
Star Gemini-15X, 100 char./sec. 15" paper.	STR-G15X	365.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	359.00
Toshiba P1351, 192 char/sec. letter quality	TOS-1351	1495.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	299.00
Okidata 92A parallel interface, 160 char/sec.	OKI-92A	379.00
Okidata 83A & parallel 15" paper	OKI-83A	549.00
Okidata 84A & parallel 15" paper	OKI-84A	929.00
Epson LX-80 10" 120 Char/sec.	EPS-LX80	239.00
Epson FX80FT, 10" 160 char./sec. with graphtrax	EPS-FX80	399.00
Epson FX100FT 15" 160 char./sec with graphtrax	EPS-FX100	599.00
Epson LQ1500, 15" corespondence quality	EPS-LQ1500	1079.00
Epson JX80 Color printer	EPS-JX80	579.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	329.00
Prowriter II, parallel 15" paper, graphics	PRO-2P	599.00
Dataproducts B-600-3, band printer 600 LPM.	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	5795.00

WORD PROCESSING PRINTERS

Starwriter F10 parallel, 40 char/sec.	PRO-F10P	499.00
NEC8810 55 char/second, serial interface	NEC-8810	1659.00
NEC8830 55 char/sec, par'l interface.	NEC-8830	1659.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1599.00
NEC2050 designed for IBM/PC 20 char/sec. par'l.	NEC-2050	689.00
Silver Reed EXP500, 14 char/sec. par'l interface	SRD-EXP500	319.00
Silver Reed EXP550 17 Char/sec par'l interface.	SRD-EXP550	429.00
Diablo 630 40 char/sec. serial	DBL-630	1569.00
Diablo 620, proportional spacing, horz.& vert. tab. 20 cps.	DBL-620	769.00
Juki 6100, 18 char./sec.	JUK-6100	399.00
Juki 6300, 40 char./sec.	JUK-6300	699.00
Comrex CR2, 5k buffer, proportional spacing, par'l.	CRX-CR2P	395.00

TERMINALS

Freedom 100, split screen, detatchable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Ampex Dialogue 125 green screen,	APX-D125G	675.00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D175A	719.00
Wyse 50, 14" green phosphor	WYS-50	595.00
Wyse 300, Eight color display, split screen.	WYS-300	1159.00
Zenith 29 terminal, VT52 compatible. detatch.ble keyboard.	ZTH-Z29	765.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char.,split screen, 22 func.	TVI-950	950.00
Televideo 970, 14" green, 132 column, European	TVI-970	1095.00

1200 BAUD

UNIVERSAL DATA

$119



The UDS-212LP is a compact desktop modem designed to obtain all its operating power entirely from the telephone line thus eliminating the need to connect to an external AC power source. NOT Hayes compatible but the ideal 1200 baud modem to connect to any CRT terminal or computer when accessing dial up data bases.

The Universal Data Division of Motorla original suggested list price on the 212/LP was $ 495. but California Digital is offering at only $119.

SMARTEAM 1200 $229



The Team 212A offers all the features of the Hayes Smart Modem 1200 for a fraction of the price. Now is your opportunity to purchase a 1200 baud modem at the price of a 300 baud modem.

MODEMS

Hayes Smartmodem 2400 baud modem	HYS-2400	6'9.00
Fujitsu 2400/1200 baud auto everything	FUJ-1935D	495.00
Team 1200 Hayes Compatible	TEM-SM1200	229.00
Wolfdata same as QUBIE 1200 baud IBM internal	WLF-PC212A	159.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	259.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
Prometheus 1200 super features	PRM-P1200	319.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark 12, 1200 baud, Hayes compatible.	SGL-MK12	239.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	69.00
Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	429.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	399.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
Penril 300/1200 industrial quality	PEN-12AD	495.00
Universal Data 103JLP, line power, auto answer.	UDS-103LP	49.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	119.00
Universal Data 212A, 1200 baud, industrial Line.	UDS-212A	199.00

PLOTTER

$219

The Comrex Comscriber I is the ideal solution to make short work of translating financial and numeric data into a graphic presentation.Many ready to run programs such as Lotus 1-2-3 Visi-on and Apple business graphics already support this plotter.

The Comscriber I features programmable paper sizes up to 8½ by 120 inches, 6 inch per second plot speed and 0.004" step size.Easy to implement Centronics interface allows the Comscriber I immediate use with the printer port of most personal computers.

The Comscriber I is manufactured for Comrex by the Enter Computer Corporation. The plotter is marketed by Heath Kit and also sold under Enters own "Sweet P" Label. This is your opportunity to purchase a plotter which was originally priced at $795 for only $219.

Also available is a support package which includes demonstration software, interface cable a multicolor pen assortment and a variety of paper and transparency material.



NEC RGB COLOR MONITOR

$259

The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White.

The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these "new" RGB monitors at a fraction of their original cost. Sanyo compatible NEC-1401/S IBM/P/C Computer compatible NEC-1401/PC

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California Digital

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F10 DAISY WHEEL PRINTER

$499

LETTER QUALITY



The TEC F-10 Daisy Wheel printer is the perfect answer to a reasonablly priced 40 character word processing printer. While this printer is " extremely" similar to C.Itoh's F-10/40 Starwriter printer. Legal counsel for the C.Itoh Company have advised us that we should refrain from referring to the TEC printer as a Starwriter.

This 40 character per second printer auto installs with Wordstar and Perfect Writer. Features extensive built-in word processing functions that allow easy adaptability and reduced software complexity. Industry standard Centronics interface provides instant compatibility with all computers equiped with a parallel printer port. The TEC F-10 accepts paper up to 15 inches in width.

These printers were originally priced to sell at over $1400. Through a special arrangment California Digital has purchase these units from a major computer manufacturer and is offering these printers at a fraction of their original cost.

Options available include tractor feed, buffered memory and an assortment of printer cables for a variety of computers.



ROULETTE FREE

California Digital is offering this $19.95 value Roulette game with clock calendar absolutely FREE with any purchase over $50.

To receive your FREE Roulette game your order must be placed by mail before the end of this month, payment must accompany your order and the FREE Roulette game must be requested.

DUAL SHUGART SUBSYSTEM

$239



The dual Shugart subsystem features two SA465 (96 tpi) 5¼" double sided disk drives. Also supplied within the subsystem is 50 watt power supply and a shielded signal cable.



$99

MEMORY

4164 DYNAMIC MEMORY 150ns

$.99 Quantity 100

DYNAMIC MEMORY		1-31	32 +	100 +
4164 150ns. 64K 128 refresh	ICM-4164150	1.39	1.19	.99
41256 150ns. 256K	ICM-41256150	6.95	6.50	6.25
4116 150ns. 16K	ICM-4116150	1.75	1.65	1.45
4116 200ns.16K	ICM-4116200	1.75	1.65	1.45
4128 for IBM/AT	ICM-4128150	6.95	6.75	6.35
DP8409 dynamic controller	ICT-8409	39.00	35.00	29.00
STATIC MEMORY				
21L02 200ns. 1K static	ICM-21L02200	1.49	1.29	1.15
21L02 450ns. 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns. 2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns. 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns. 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns. 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4 200ns. 2K x 8	ICM-6116200	3.95	3.85	3.70
6116 P3 150ns. 2K x 8	ICM-6116150	4.55	4.35	4.15
EPROMS				
2708 450ns. 1K x 8	ICE-2708	4.95	4.75	4.55
2716 450ns. 2K x 8	ICE-2716	4.50	4.25	3.97
2716TMS 450ns. Tri-voltage	ICE-2716TMS	7.95	7.65	7.25
2732 450ns. 4K x 8	ICE-2732	4.50	3.75	3.55
2764 350ns. 8K x 8	ICE-2764	5.95	5.75	6.25
27128 350ns. 16K x 8	ICE-27128	7.95	7.35	6.95

Shugart 604 WINCHESTER

$99



These 6.7 Megabyte drives are new units recently released by the Shugart division of Xerox. The Shugart 604 is fully 506 industry compatible. Each drive is tested before shipment and is supplied with a 90 day warranty. SHU-604

Five Inch Winchester Hard Disk Drives		
FUJITSU M2235AS 27 Meg.	899	859
RODIME RO-208 53 Meg.	1589	1493
MAXTOR XT10140 140 Meg.	3895	3785
SHUGART 712 13 Meg. ½ Ht	495	465
SHUGART 604 6.7 Meg.	99	89
TANDON 502 10 Meg.	419	395
TANDON 503 19 Meg.	695	675
SEAGATE 225 25 Meg.	695	625

TEAC 55B 48 TPI

	One	Two	Ten
Five Inch Double Sided Drives			
TEAC FD55B half height	99	95	89
TEAC FD55F 96 TPI, half ht.	119	115	109
CONTROL DATA 9409 PC	169	159	155
SHUGART SA455 Half Height	99	95	89
SHUGART SA465 ½ Ht. 96TPI	99	95	89
TANDON 100-2 full height	129	125	119
TANDON 101-4 96TPI full ht.	199	189	179
MITSUBISHI 4851 half height	139	135	129
MITSUBISHI 4853 96/TPI½ Ht.	155	149	139
MITSUBISHI 4854 8" elec.	295	285	275
QUME 142 half height	119	105	99
Eight Inch Single Sided Drives			
SHUGART 801R			
SIEMENS FDD 100-8	119	115	109
TANDON 848E-1 Half Height	369	359	349
Eight Inch Double Sided Drives			
SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	319	319	313
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2896-63 ½ Ht.	459	449	409

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- Professional Molded Packaging and Design
- High Quality 100 Watt Switching Supply
- Complete Integrated System
- Microsoft Compatible Mouse Function

The system is not a Taiwan or Korean knock-off. Each component is specifically designed and specified to meet the highest performance and reliability standards in the industry. It represents the best that Japanese craftsmen have to offer and you will be equally proud to own one of your own. ACP has a limited quantity of these systems in several different configurations. IBM PC-DOS™ v1.1/2.1, MS-DOS™ v2.11 and Concurrent v3.1 compatible. We have found no known incompatibility with any IBM PC application. Our technical staff has 8.5 Megabytes of various MS-DOS software packages installed including Lotus 1-2-3 and Flight Simulator. Each system comes complete with a 90 day warranty.

ACP Base System Consists of:

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- Color or Monochrome Controller
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Base System A (as above) $995.00

	SYSTEM CONFIGURATION	Est IBM List*	Your Price
SYSTEM A	Base System (see left) PC with 360K Floppy, Keyboard & Mouse.	$2100.00	**$995.00**
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SYSTEM C	Base System plus 12" Green Monitor with Detachable Tilt/Swival Base.	$2575.00	**$1399.00**
SYSTEM D	Base System plus 12" Color Monitor with Detachable Tilt/Swival Base.	$2995.00	**$1699.00**
SYSTEM E	Base System plus Clr Monitor, 10Mb Hard Disk and Boot Diagnostics.	$5000.00	**$2095.00**
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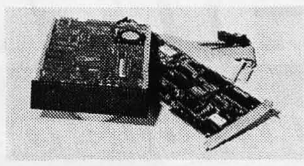


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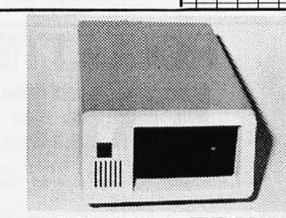
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22 Pin ST/LP	.29	.27
24 Pin ST/LP	.29	.27
28 Pin ST/LP	.39	.32
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Persyst Shortport Color	Call
Persyst Mini Mono	Call
Persyst +I Time Spectrum w/64K	179.95
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Hayes Smartmodem Compatible
1200 Baud. External. Sold for 399.00
$219.00

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2N2218A	.45	TIP30A	2/1.00
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2N2905	.45	TIP32A	2/1.25
2N2907	.25	1N4148	25/1.00
2N3055	.69	1N751	5/1.00
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2N3772	1.69	MPQ2232	1.49

OPTO ISOLATORS

MCT-2	$ .59	4N33	$ .89
MCT-6	1.39	4N35	1.25
MCT-66	.55	4N37	1.25
MCA-255	1.69	4N38	.98
4N26	.65	TIL117	.79
4N27	.65	SPX33	.29
4N28	.69	4N25	5/1.00

LED LAMPS

	1-99	100
Jumbo Red	$ .09	$ .08
Jumbo Green	.17	.15
Jumbo Yellow	.17	.15
Mini Size Red	.10	.09
Mini Size Green	.19	.16
Mini Size Yellow	.19	.16

SPECIAL VALUES!

MCM68705 EPROM	$9.95
6116/2016-150mS	10/19.95
DB-25P Male	10/17.50
DB-25S Female	10/19.95
2732A-2	10/29.95
2716DC-450mS	10/24.50
2764-450mS	10/29.95

CALL ACP FOR ALL YOUR VOLUME IC REQUIREMENTS

EDGE CONNECTORS

	1-99	100
S-100 ST	$3.95	$3.25
S-100 WW	4.75	4.10
44 Pin ST	2.75	2.60
44 Pin WW	4.75	4.25
72 Pin ST	6.50	6.10
72 Pin WW	7.25	6.95

D-SUBMINIATURE

	1-24	25
DB25S (Female	$3.10	$2.90
DB25P (Male)	2.40	2.29
Hood $1.25	Mtg H/W $ .99	
DE37S (Female)	$5.95	$5.75
DE37P (Male)	5.25	5.10
Hood $1.75	Mtg H/W $ .99	
DD50S (Female)	$8.95	$8.65
DD50P (Male)	6.00	5.75
Hood $3.25	Mtg H/W $ .99	

(OTHER STYLES IN CATALOG)

CENTRONICS

IDC 36 Pin Male	$8.95
IDC 36 Pin Female	9.49
Solder 36 Pin Male	7.49
Solder 36 Pin Female	8.95

(CALL TOLL FREE FOR IDC's)

IDC CONNECTORS

IDC TYPE	ACP NO	NUMBER OF CONTACTS 10	20	26	34	40	50
Solder Header	IDHxxS	.79	1.20	1.65	2.10	2.40	3.00
Rt Angle Solder Header	IDHxxSR	.79	1.20	1.65	2.10	2.40	3.00
Ribbon Header Socket	IDSxx	.75	.95	1.35	1.50	1.85	2.10
Ribbon Header	IDMxx	—	5.25	5.95	6.75	7.25	8.25
Ribbon Edgecard	IDExx	1.70	2.15	2.50	2.60	3.70	3.95
Wirewrap Header	IDHxxW	1.80	2.90	3.75	4.25	4.95	6.50
Rt Angle W/W Header	IDHxxWR	1.99	3.10	4.10	4.20	4.60	7.15

NOTE: To order insert number of contacts in place of xx in ACP part number.
ORDER QUANTITY OF 50pcs (mixed) AND TAKE AN ADDITTIONAL 10% OFF.

OKIDATA PRINTERS

Okimate 20 Color Printer	$139.00	Okidata 84 (200cps, Parallel)	$799.00
Plug-N-Print for Okidata 20	69.00	Okidata 84 (200cps, Serial)	949.00
Okidata 182 (120cps, Graphics)	259.00	Tractor for Okidata 192	44.00
Okidata 192 (160cps, Graphics)	349.00	Tractor for Okidata 92	54.00
Okidata 193 (160cps, 15" Paper)	549.00	2K Serial Board for Okidata 192/193	69.00
Okidata 92 (160cps, Graphics)	349.00	2K Serial Board for Okidata 92/93	99.00
Okidata 93 (160cps, 15" Paper)	599.00	Extra Ribbon	5.00

6800

68000	$19.95	6810	$ 2.85	6850	$ 3.25
68000L10	39.95	6820	3.75	6852	5.65
6800	2.90	6821	2.90	6860	7.90
6802	7.75	6828	14.50	6875	6.75
6803	18.95	6840	12.75	6880	2.20
6809E	9.50	6845	11.95	68047	22.95

6500

6502	$4.50	6504	$6.75	6522	$5.25
6502A	6.90	6507	9.75	6532	9.50
6502B	9.50	6520	4.25	6551	11.50

8000

8035	$ 5.75	8214	$ 3.75	8259	$ 6.75
8039	5.75	8216	1.95	8271	69.95
8080A	2.95	8224	2.20	8275	26.95
8085A	4.90	8226	1.95	8279	8.75
80C85A	9.95	8228	3.40	8282	6.25
8086	24.50	8237	13.75	8283	6.25
8087-2	129.95	8237-5	15.95	8284	5.50
8088	17.50	8238	4.25	8286	6.45
8089	88.95	8243	3.95	8287	6.45
8155	6.75	8250	10.50	8288	11.95
8156	6.75	8251	4.25	8289	44.95
8185	26.95	8251A	5.95	8292	12.95
8202	23.95	8253	6.75	8741	27.95
8203	37.95	8255	4.25	8748	24.50
8205	3.25	8255A	5.95	8749	24.50
8212	1.95	8257	5.75	8755A	34.95

Z-80

	2.5MHz	"A" 4.0MHz	"B" 6.0MHz
Z80-CPU	2.25	2.75	6.95
Z80-CTC	2.50	3.75	9.25
Z80-DART	7.50	8.50	17.95
Z80-DMA	8.00	8.95	17.95
Z80-PIO	2.95	3.50	9.50
Z80-SIO/0	8.50	9.50	22.95
Z80-SIO/1	8.50	9.50	—
Z80-SIO/2	8.50	9.50	22.95
Z80-SIO/9	8.50	9.50	—

Z8030	$34.95	Z8001	$34.95	Z6132	$32.95
Z8530	34.95	Z8002	34.95	Z8671	37.95

DISK CONTROLLERS

uPD765	$24.95	1797	$21.95	6843	$28.95
1771	15.95	2791	32.95	8272	19.95
1791	22.75	2793	32.95	1691	6.95
1793	21.50	2795	32.95	2143	6.95
1795	21.50	2797	27.95	9216	12.95

CRT CONTROLLERS

6845	$11.95	8275	$28.50	TMS9918	$39.50
68B45	17.95	7220	34.95	8350	39.95
6847	11.50	5027	17.95	6545	14.95
46505	14.75	5037	21.95	8002	19.95
68047	19.50	NEC7220 Graphics			34.95

UARTS/USARTS

1602B	$3.95	2350	$ 8.95	IM6403	$ 8.75
1013A	3.95	8250	10.50	TMS5501	14.95
1015A	6.75	IM6402	7.75	2651	8.95

EPROMS

1702 (1mS)	$ 3.90	2732A-4 (450nS)	$ 4.50
2708 (450nS)	3.65	2732A (250nS)	6.95
2758 (5V)	5.50	2732A-2 (200nS)	8.95
2716 (450nS)	3.75	2764 (450nS)	4.50
2716 (350nS)	5.50	2764 (250nS)	6.50
2516 (5V)	5.50	2764 (200nS)	8.50
TMS2716	7.50	TMS2564 (450nS)	9.95
TMS2532	5.60	MCM68764 (450nS)	19.95
2732 (450nS)	4.60	MCM68766 (350nS)	21.95
2732 (250nS)	6.00	27128-3 (300nS)	9.50
2732 (200nS)	8.00	27128 (250nS)	15.95
CMOS EPROMS		27C32	$9.95
27C16	$8.95	27C64	12.95

STATIC RAMS

2101 (450nS)	$1.89	MK4118	$4.95
21L02 (450nS)	.99	TMM2016-2 (200nS)	3.10
2102-1 (450nS)	.79	TMM2016-15 (150n)	3.95
21L02-2 (250nS)	1.39	TMM2016-1 (100nS)	3.00
2111 (450nS)	2.75	HM6116P-4 (200nS)	4.75
2112 (450nS)	2.75	HM6116P-3 (150nS)	3.25
2114 (450nS)	1.45 8/9.50	HM6116P-2 (120nS)	5.75
2114L-4 (450n)	1.69 8/12.50	HM6116LP-4 (LP)	3.60
2114L-3 (300n)	1.79 8/13.30	HM6116LP-3 (LP)	3.95
2114L-2 (200n)	1.89 8/13.90	HM6116LP-2 (LP)	3.95
2147 (55nS)	4.50	Z6132 (300nS)	32.95
4044-4 (450nS)	3.25	HM6264P-15 (150)	14.95
4044-3 (300nS)	3.75	HM6264LP-15 (LP)	16.95
4044-2 (200nS)	4.35	74S189 (35nS)	1.85
UPD410 (100nS)	3.75	93415 (50nS)	3.95
5101 (CMOS)	3.50	93425 (50nS)	3.95

DYNAMIC RAMS

4027 (250nS)	$1.29	TMS4406 (200nS)	$6.95
1103 (300nS)	.79	TMS4416 (150nS)	$7.75
4116N-2 (150nS)	1.29 8/ 9.95	41256-150 (150n)	8.95
4116N-3 (200nS)	1.19 8/ 8.25	41256-200 (200n)	7.95
4116N-4 (250nS)	.89 8/ 5.99	TMS4050 (300nS)	1.85
4164N-150 (150n)	1.59 9/11.95	TMS4060 (300nS)	1.85
4164N-200 (200n)	1.49 9/10.00	MM5280 (300nS)	1.85
4164N-120 (120nS)	6.25	UPD411 (300nS)	1.85
TMS4164 (150nS)	5.95	MM5298 (250nS)	1.85

DISK SPECIAL (IBM PC DSDD)

$1.00 EACH — PACKAGE OF 25
"IBM PC®" DS/DD, Hub Rings, Tyvac Cover, Major Mfgr.
WOW! Supply Limited

5¼" DISKETTES	1 Box	10 Box
VERBATIM 525-01 SS/DD	$22.95	$19.95
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VERBATIM 3½" MF350 (MAC)	32.00	29.00
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4000	$ .26	4028	$ .65	4059	$7.90	4505	8.95
4001	.22	4029	.75	4060	.85	4506	1.10
4002	.22	4030	.39	4066	.39	4507	1.10
4006	.79	4031	3.25	4069	.28	4508	1.90
4007	.22	4032	2.15	4070	.35	4510	.79
4008	.95	4034	1.91	4071	.28	4511	.79
4009	.39	4035	.79	4072	.28	4512	.79
4010	.39	4037	1.95	4073	.28	4514	1.18
4011	.24	4040	.75	4075	.28	4515	1.79
4012	.24	4041	.75	4076	.75	4516	1.19
4013	.35	4042	.65	4077	.35	4518	.85
4014	.75	4043	.85	4078	.35	4520	.75
4015	.39	4044	.69	4081	.29	4555	.95
4016	.35	4046	.80	4082	.29	4556	.95
4017	.65	4047	.89	4085	.95	4566	1.35
4018	.79	4048	.99	4086	.95	80C95	1.50
4019	.39	4049	.35	4093	.45	80C97	.49
4020	.69	4050	.34	4094	2.95	MC14408	12.95
4021	.69	4051	.75	4098	1.90	MC14409	12.95
4022	.69	4052	.75	4099	1.85	MC14410	9.95
4023	.25	4053	.75	4501	.69	MC14411	11.95
4024	.59	4055	3.95	4502	.95	MC14412	12.95
4025	.25	4056	2.95	4503	.49	MC14419	4.95
4027	.45	CALL FOR 74HC					

74C00

74C00	$.29	74C74	$.65	74C161	$1.15	74C373	$2.35
74C02	.29	74C85	1.89	74C175	1.15	74C374	2.35
74C04	.29	74C90	1.15	74C240	1.89	74C901	.59
74C08	.35	74C93	1.15	74C244	1.89	74C922	4.45
74C10	.35	MORE 74C IN STOCK — ALSO IN CATALOG					

LINEAR

LM108AH	$3.95	NE590	$2.45	LM3909	.98
LM300H	.99	NE592	2.70	LM3914	$2.95
LM301N	.35	LM709N	.55	LM3915	2.95
LM304H	1.89	LM709H	1.90	LM3916	2.95
LM305H	.95	LM710	.68	MC4024	3.75
LM306H	4.75	LM711	.75	MC4044	4.35
LM307N	.40	LM715	3.95	RC4131	3.75
LM308CN	.65	LM723N	.55	RC4136	1.19
LM310CN	1.65	LM723H	.75	RC4151	3.75
LM311CN	.62	LM733	.98	CA3023	2.75
LM312H	1.75	LM739	1.85	CA3039	1.25
LM318CN	1.45	LM741CN	.33	CA3046	1.25
LM318H	1.55	LM741H	.40	CA3059	2.85
LM319N	1.19	LM741N	.29	CA3060	2.85
LM320 (see VRs)		LM747	.65	CA3065	1.69
LM324N	.55	LM748	.55	CA3080	1.10
LM339N	.95	LM1014	1.15	CA3081	1.60
LM340 (see VRs)		LM1303	1.90	CA3082	1.60
LM348N	.95	LM1310	1.45	CA3083	1.55
LM358CN	.65	MC1330	1.65	CA3086	.80
LM359	1.75	MC1349	1.85	CA3089	2.95
LM360N	2.95	MC1350	1.15	CA3096	3.45
LM370N	4.95	MC1358	1.65	CA3130	1.29
LM373N	3.95	MC1372	6.75	CA3140	1.15
LM376N	3.75	LM1414	1.55	CA3146	1.79
LM377N	1.90	LM1558H	2.99	CA3160	1.49
LM380CN	.85	LM1800	2.35	LM13080	1.25
LM380N	1.05	LM1812	8.10	LM13600	1.45
LM381N	1.59	LM1830	3.40	LM13700	1.45
LM382N	1.35	LM1871	5.45	LF347	2.19
LM383N	1.95	LM1872	5.45	LF351	.60
LM384N	1.75	LM1877	3.20	LF353	.99
LM386N	.89	LM1889	1.90	LF355	1.10
LM387N	1.29	LM1896	1.70	LF356	1.10
LM389N	1.15	ULN2001	1.95	LF357	1.39
LM392N	.69	ULN2003	1.49	TL071CP	.79
LM723N	.48	XR2206	3.75	TL072CP	1.35
LM723H	.55	XR2207	2.90	TL074CN	1.90
NE531	2.85	XR2208	2.40	TL081CP	.59
NE555	.35	XR2211	3.75	TL084CN	1.90
NE556	.65	LM2877P	2.00	TL494	4.10
NE558	1.49	LM2878P	2.25	TL496	1.65
NE561	23.50	LM2900	.83	TL497	3.20
NE564	2.85	LM2901	.99	MC3423	1.49
LM565	.95	LM2903	.69	MC3453	4.95
LM566	1.45	LM2907	2.45	MC3456	1.29
LM567	.85	LM2917	2.85	MC3459	3.75
NE570	3.85	LM3900	.55	MC3469	5.25
NE571	2.90	LM3905	1.15	MC3470	7.95

VOLTAGE REGULATORS

7805T Also 8, 12, 15, 24V	.69	7905K Also 12, 15, 24V	1.39
78L05, 12, 15V	.65	79L05, 12, 15V	.75
78M06C	.89	LM309K	1.25
78MG/79MG	1.49	LM317H/K	1.25/3.85
78H05KC	8.75	LM323K	4.85
7805K Also 12, 15, 24V	1.29	LM337K	3.75
7905T Also 8, 12, 15, 24V	.79	LM338K	6.75
		LM350T	4.55
		LM350K	4.75

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MC14411	$11.50	58174	$11.25	95H90	$ 9.25
BR1941	11.50	5832	3.75	76477	3.75
34702	12.50	AY52376	11.50	76488	5.75
5016	14.95	AY53600	11.50	76489	8.75
8116	10.50	2513-001U	9.50	AY38910	7.95
5307	10.50	2513-002L	9.50	AY38912	7.95
MC4024	3.75	UPD7201	27.95	SSI-263	36.95
8038	3.75	3341	4.50	Votrax	39.95
5369	3.50	11C90	13.25	Digitalker	34.95
58167	12.25	MC15906	2.95	LM13600N	1.95
SP1000 Speech	$9.95	TR1863 5V UART			$4.25

DATA AQUISITION

ADC0800	$14.95	ADC0817	$9.75	1408L6	$1.95
ADC0804	3.45	DAC0800	4.75	1408L8	2.85
DAC0806	1.90	DAC0808	2.85	DAC100	7.95
ADC0809	4.45	DAC1020	7.95	DAC08	7.95
ADC0816	14.25	DAC1022	5.85	DAC01	6.95
AD7523JN	1.99	LF353N	1.99	LF13201N	1.99

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64K UPGRADE (Set of 9) **$10.00**
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7400

7400	$ .18	7446	$ .68	74123	$ .45	74176	$ .69
7401	.18	7447	.65	74125	.42	74177	.69
7402	.18	7448	.68	74126	.44	74179	1.34
7403	.18	7450	.19	74128	.49	74180	.75
7404	.18	7451	.19	74132	.45	74181	1.75
7405	.23	7453	.19	74136	.75	74182	1.15
7406	.49	7454	.19	74141	.85	74184	2.25
7407	.49	7459	.25	74142	2.95	74185	2.25
7408	.24	7460	.37	74143	3.70	74190	.67
7409	.19	7470	.29	74144	2.95	74191	.67
7410	.19	7472	.29	74145	.59	74192	.67
7411	.24	7473	.33	74147	1.49	74193	.67
7412	.38	7474	.34	74148	1.19	74194	.67
7413	.34	7475	.38	74150	1.09	74195	.67
7414	.49	7476	.34	74151	.55	74196	.75
7416	.49	7479	4.60	74152	.67	74197	.86
7417	.49	7480	.69	74153	.53	74198	1.15
7420	.19	7482	.95	74154	1.19	74199	1.15
7421	.35	7483	.45	74155	.69	74221	1.19
7422	.45	7485	.55	74156	.59	74251	.75
7423	.58	7486	.35	74157	.59	74273	1.65
7425	.29	7489	1.95	74158	1.65	74276	1.89
7426	.29	7490	.35	74159	1.58	74279	.75
7427	.25	7491	.65	74160	.79	74283	1.40
7428	.55	7492	.45	74161	.69	74284	2.90
7430	.18	7493	.35	74162	.69	74285	2.90
7432	.29	7494	.85	74163	.69	74290	1.49
7437	.25	7495	.50	74164	.69	74298	1.49
7438	.29	7496	.69	74165	.69	74365	.55
7439	.58	7497	2.70	74166	.85	74366	.55
7440	.19	74100	1.50	74167	2.75	74367	.55
7441	.79	74107	.24	74170	1.25	74368	.55
7442	.45	74109	.37	74172	4.75	74390	1.45
7443	1.15	74116	1.45	74173	.69	74393	1.33
7444	1.15	74121	.29	74174	.69	74490	2.25
7445	.68	74122	.44	74175	.69		

74LS00

74LS00	$ .22	74LS113	$ .38	74LS247	$ .74
74LS01	.22	74LS114	.39	74LS248	.98
74LS02	.22	74LS122	.45	74LS249	.98
74LS03	.22	74LS123	.95	74LS251	.59
74LS04	.24	74LS124	2.75	74LS253	.59
74LS05	.25	74LS125	.49	74LS257	.59
74LS08	.27	74LS126	.49	74LS258	.59
74LS09	.28	74LS132	.59	74LS259	2.95
74LS10	.25	74LS136	.39	74LS260	.59
74LS11	.33	74LS138	.59	74LS261	2.49
74LS12	.33	74LS139	.59	74LS266	.55
74LS13	.39	74LS145	1.19	74LS273	1.45
74LS14	.59	74LS148	1.38	74LS275	3.29
74LS15	.33	74LS151	.55	74LS279	.59
74LS20	.26	74LS153	.55	74LS283	.68
74LS21	.29	74LS154	1.49	74LS290	.88
74LS22	.29	74LS155	.69	74LS293	.78
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.69	74LS324	1.75
74LS30	.25	74LS160	.69	74LS347	1.95
74LS32	.33	74LS161	.69	74LS348	1.95
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74LS38	.39	74LS164	.69	74LS363	1.29
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74LS42	.44	74LS166	1.90	74LS366	.48
74LS47	.74	74LS168	1.15	74LS367	.45
74LS48	.74	74LS169	1.15	74LS368	.45
74LS51	.25	74LS170	1.40	74LS373	1.39
74LS54	.29	74LS173	.67	74LS374	1.33
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74LS73	.39	74LS175	.67	74LS377	1.38
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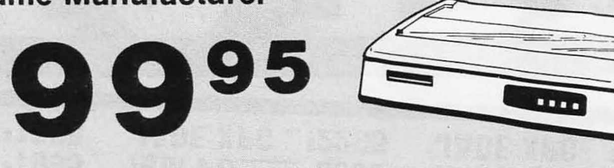
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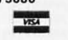


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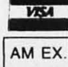
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41128-150	131072x1	(150ns)(5v)	13.95
41256-200	262144x1	(200ns)(5v)	3.95
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5v=Single 5 Volt Supply   REFRESH=Pin 1 Refresh

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2732A	4096x8	(250ns)(5V)(21V PGM)	6.95
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2764	8192x8	(450ns)(5V)	3.75
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MCM68764	8192x8	(450ns)(5V)(24 pin)	24.95
MCM68766	8192x8	(350ns)(5V)(24 pin)	42.95
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27128	16384x8	(250ns)(5V)	5.95
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5V=Single 5 Volt Supply   21V PGM=Program at 21 Volts

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74LS09	.29	74LS197	.79
74LS10	.25	74LS221	.89
74LS11	.35	74LS240	.95
74LS12	.35	74LS241	.99
74LS13	.45	74LS242	.99
74LS14	.59	74LS243	.99
74LS15	.35	74LS244	1.29
74LS20	.25	74LS245	1.49
74LS21	.29	74LS247	.75
74LS22	.25	74LS248	.99
74LS26	.29	74LS249	.99
74LS27	.29	74LS251	.59
74LS28	.35	74LS253	.59
74LS30	.25	74LS257	.59
74LS32	.29	74LS258	.59
74LS33	.55	74LS259	2.75
74LS37	.35	74LS260	.59
74LS38	.35	74LS261	2.25
74LS40	.25	74LS266	.55
74LS42	.49	74LS273	1.49
74LS47	.75	74LS275	3.35
74LS48	.75	74LS279	.49
74LS49	.75	74LS280	1.98
74LS51	.25	74LS283	.69
74LS54	.29	74LS290	.89
74LS55	.29	74LS293	.89
74LS63	1.25	74LS295	.99
74LS73	.39	74LS298	.89
74LS74	.35	74LS299	1.75
74LS75	.39	74LS322	5.95
74LS76	.39	74LS323	3.50
74LS78	.49	74LS324	1.75
74LS83	.60	74LS348	2.50
74LS85	.69	74LS352	1.29
74LS86	.39	74LS353	1.29
74LS90	.55	74LS363	1.35
74LS91	.89	74LS364	1.95
74LS92	.55	74LS365	.49
74LS93	.55	74LS366	.49
74LS95	.75	74LS367	.45
74LS96	.89	74LS368	.45
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74LS163	.65	74LS688	2.40
74LS164	.69	74LS689	3.20
74LS165	.95	81LS95	1.49
74LS166	1.95	81LS96	1.49
74LS168	1.75	81LS97	1.49
74LS169	1.75	81LS98	1.49
74LS170	1.49	25LS2518	4.13
74LS173	.69	25LS2521	2.80
74LS174	.55	25LS2538	3.74
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8259	6.90
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8271	79.95
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7406	.29	7492	.50	74178	1.15
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7408	.24	7494	.65	74180	.75
7409	.19	7495	.55	74181	2.25
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7421	.35	74116	1.55	74194	.85
7422	.35	74120	1.20	74195	.85
7423	.29	74121	.29	74196	.79
7425	.29	74122	.45	74197	.75
7426	.29	74123	.49	74198	1.35
7427	.29	74125	.45	74199	1.35
7428	.45	74126	.45	74221	1.35
7430	.19	74128	.55	74246	1.35
7432	.29	74132	.45	74247	1.25
7433	.45	74136	.50	74248	1.85
7437	.29	74141	.65	74249	1.95
7438	.29	74142	2.95	74251	.75
7439	.79	74143	4.95	74259	2.25
7440	.19	74144	2.95	74265	1.35
7442	.49	74145	.60	74273	1.95
7443	.65	74147	1.75	74276	1.25
7444	.69	74148	1.20	74278	3.11
7445	.69	74150	1.35	74279	.75
7446	.69	74151	.55	74283	2.00
7447	.69	74152	.65	74284	3.75
7448	.69	74153	.55	74285	3.75
7450	.19	74154	1.25	74290	.95
7451	.23	74155	.75	74293	.75
7453	.23	74156	.65	74298	.85
7454	.23	74157	.55	74351	2.25
7460	.23	74159	1.65	74365	.65
7470	.35	74160	.85	74366	.65
7472	.29	74161	.69	74367	.65
7473	.34	74162	.85	74368	.65
7474	.33	74163	.69	74376	2.20
7475	.45	74164	.85	74390	1.75
7476	.35	74165	.85	74393	1.35
7480	.59	74166	1.00	74425	3.15
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4018	.79	4585	.75
4019	.39	45151	12.95
4020	.75	4702	12.95
4021	.79	4724	1.50
4022	.79	74C00	.35
4023	.29	74C02	.35
4024	.65	74C04	.35
4025	.29	74C08	.35
4026	1.65	74C10	.35
4027	.45	74C14	.59
4028	.69	74C20	.35
4029	.79	74C30	.35
4030	.39	74C32	.39
4034	1.95	74C42	1.29
4035	.85	74C48	1.99
4040	.75	74C73	.65
4041	.75	74C74	.65
4042	.69	74C76	.80
4043	.85	74C83	1.95
4044	.79	74C85	1.95
4046	.85	74C86	.39
4047	.95	74C89	4.50
4048	.69	74C90	1.19
4049	.35	74C93	1.75
4050	.35	74C95	.99
4051	.79	74C150	5.75
4052	1.99	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4077	.59	74C192	1.49
4078	.29	74C193	1.49
4081	.29	74C195	1.39
4082	.29	74C200	5.75
4085	.95	74C221	1.75
4086	.95	74C244	2.25
4093	.49	74C373	2.45
4094	2.99	74C374	2.45
4098	2.49	74C901	.39
4099	1.95	74C902	.85
14409	12.95	74C903	.85
14410	12.95	74C905	10.95
14411	11.95	74C906	.95
14412	12.95	74C907	1.00
14419	7.95	74C908	2.00
14433	14.95	74C909	2.75
14490	4.95	74C910	9.95
4502	.95	74C911	8.95
4503	.65	74C912	8.95
4507	1.25	74C914	1.95
4508	1.95	74C915	1.19
4510	.85	74C918	2.75
4511	.85	74C920	17.95
4512	.85	74C921	15.95
4514	1.25	74C922	4.49
4515	1.79	74C923	4.95
4516	1.55	74C925	5.95
4518	.89	74C926	7.95
4519	.39	74C927	7.95
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4521	4.99	74C929	19.95
4522	1.25	80C95	.85
4526	1.25	80C96	.95
4527	1.95	80C97	.95
4528	1.19	80C98	1.20
4529	2.95		

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC175	.99
74HC02	.59	74HC193	1.25
74HC04	.59	74HC194	1.04
74HC08	.59	74HC195	1.09
74HC10	.59	74HC238	1.35
74HC11	.59	74HC240	1.89
74HC14	.79	74HC241	1.89
74HC20	.59	74HC242	1.89
74HC27	.59	74HC243	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC251	.89
74HC74	.75	74HC257	.85
74HC75	.85	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC367	.99
74HC125	1.19	74HC373	2.29
74HC132	1.19	74HC374	2.29
74HC138	.99	74HC393	1.39
74HC139	.99	74HC4017	1.99
74HC151	.89	74HC4020	1.39
74HC153	.89	74HC4024	1.59
74HC154	2.49	74HC4040	1.39
74HC157	.89	74HC4049	.89
74HC161	1.15	74HC4050	.89
74HC164	1.25	74HC4060	1.29
74HC166	2.95	74HC4511	2.39
74HC174	.99	74HC4538	2.29

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT175	1.09
74HCT02	.69	74HCT193	1.39
74HCT04	.69	74HCT194	1.19
74HCT08	.69	74HCT195	1.29
74HCT10	.69	74HCT238	1.49
74HCT11	.69	74HCT240	2.19
74HCT14	.89	74HCT241	2.19
74HCT20	.69	74HCT242	2.19
74HCT27	.69	74HCT243	2.19
74HCT30	.69	74HCT244	2.19
74HCT32	.79	74HCT245	2.19
74HCT51	.69	74HCT251	1.09
74HCT74	.85	74HCT257	.99
74HCT75	.95	74HCT259	1.59
74HCT85	1.49	74HCT273	2.09
74HCT86	.79	74HCT299	5.25
74HCT93	1.29	74HCT367	1.09
74HCT125	1.29	74HCT373	2.49
74HCT132	1.29	74HCT374	2.49
74HCT138	1.15	74HCT393	1.59
74HCT139	1.15	74HCT4017	2.19
74HCT151	1.05	74HCT4020	1.59
74HCT153	1.05	74HCT4024	1.79
74HCT154	2.99	74HCT4040	1.59
74HCT157	.99	74HCT4049	.99
74HCT161	1.29	74HCT4050	.99
74HCT164	1.39	74HCT4060	1.49
74HCT166	3.05	74HCT4511	2.69
74HCT174	1.09	74HCT4538	2.59

VOLTAGE REGULATORS

TO-220 CASE PACKAGE

7805T	.75	7905T	.85
7808T	.75	7908T	.85
7812T	.75	7912T	.85
7815T	.75	7915T	.85
7824T	.75	7924T	.85

TO-3 CASE PACKAGE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49

TO-92 CASE PACKAGE

78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79

OTHER VOLTAGE REGS

78M05C	5volt	½amp	TO-220	.35
LM323K	5volt	3amp	TO-3	4.95
LM338K	Adj.	5amp	TO-3	3.95
78H05K	5volt	5amp	TO-3	9.95
78H12K	12volt	5amp	TO-3	9.95
78P05K	5volt	10amp	TO-3	14.95
UA78S40	FAIRCHILD		DIP	1.95

LINEAR

LM301	.34	NE570	3.95
LM301H	.79	NE571	2.95
LM307	.45	NE590	2.50
LM308	.69	NE592	.98
LM308H	1.15	LM709	.59
LM309H	1.95	LM710	.75
LM309K	1.25	LM711	.79
LM310	1.75	LM723	.49
LM311	.64	LM723H	.55
LM311H	.89	LM733	.98
LM312H	1.75	LM741	.35
LM317K	3.95	LM741N-14	.35
LM317T	1.19	LM741H	.40
LM318	1.49	LM747	.69
LM318H	1.59	LM748	.59
LM319H	1.90	LM1014	1.19
LM319	1.25	LM1303	1.95
LM320	see7900	LM1310	1.49
LM322	1.65	MC1330	1.69
LM323K	4.95	MC1349	1.89
LM324	.59	MC1350	1.19
LM329	.65	MC1358	1.69
LM331	3.95	MC1372	6.95
LM334	1.19	LM1414	1.59
LM335	1.40	LM1458	.59
LM336	1.75	LM1488	.69
LM337T	1.95	LM1489	.69
LM337K	3.95	LM1496	.85
LM338K	3.95	LM1558H	3.10
LM339	.99	LM1800	2.37
LM340	see7800	LM1812	8.25
LM348	.99	LM1830	3.50
LM350K	4.95	LM1871	5.49
LM350T	4.60	LM1872	5.49
LM358	.69	LM1877	3.52
LM359	1.79	LM1889	1.95
LM376	3.75	LM1896	1.75
LM377	1.95	ULN2003	1.29
LM378	2.50	XR2206	3.75
LM379	4.50	LM2877	2.05
LM380	.89	LM2878	2.25
LM380N-8	1.10	LM2900	.85
LM381	1.60	LM2901	1.00
LM382	1.60	MPQ2907	1.95
LM383	1.95	LM2917	2.95
LM384	1.95	MC3487	2.95
LM386	.89	LM3900	.59
LM387	1.40	LM3905	1.25
LM389	1.35	LM3909	.98
LM390	1.95	LM3911	2.25
LM392	.69	LM3914	3.95
LM393	1.29	LM3915	3.95
LM394H	4.60	LM3916	3.95
LM399H	5.00	MC4024	3.95
NE531	2.95	MC4044	4.50
NE555	.34	RC4136	1.25
NE556	.65	RC4151	3.95
NE558	1.50	LM4250	1.75
NE564	2.95	LM4500	3.25
LM565	.99	RC4558	.69
LM566	1.49	LM13600	1.49
LM567	.89	LM13700	1.45

H=TO-5 CAN, K=TO-3, T=TO-220

RCA

CA3023	2.75	CA3083	1.55
CA3039	1.29	CA3086	.80
CA3046	1.25	CA3089	2.99
CA3059	2.90	CA3096	3.49
CA3060	2.90	CA3130	1.30
CA3065	1.75	CA3140	1.15
CA3080	1.10	CA3146	1.85
CA3081	1.65	CA3160	1.19
CA3082	1.65	CA3183	.99

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75108	1.49	75453	.39
75110	1.95	75454	.39
75150	1.95	75477	1.29
75154	1.95	75491	.79
75160	4.95	75492	.79
75188	1.25	75493	.89
75189	1.25	75494	.89

BI FET

TL066	.99	LF347	2.19
TL071	.79	LF351	.60
TL072	1.00	LF353	1.00
TL074	2.19	LF355	1.10
TL081	.79	LF356	1.10
TL082	1.19	LF357	1.40
TL083	1.19	LF411	1.29
TL084	2.19	LF412	1.99

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	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		9	8,000	$83.00
PE-14T	x	9	8,000	$119.00
PE-24T	x	12	9,600	$175.00
PL-265T	x	30	9,600	$255.00
PR-125T	x	25	17,000	$349.00
PR-320T	x	42	17,000	$595.00

TRANSISTORS

2N918	.50	2N3772	1.85
MPS918	.25	2N3903	.25
2N2102	.75	2N3904	.10
2N2218	.50	2N3906	.10
2N2218A	.50	2N4122	.25
2N2219	.50	2N4123	.25
2N2219A	.50	2N4249	.25
2N2222	.25	2N4304	.75
PN2222	.10	2N4401	.25
MPS2369	.25	2N4402	.25
2N2484	.25	2N4403	.25
2N2905	.50	2N4857	1.00
2N2907	.25	PN4916	.25
PN2907	.13	2N5086	.25
2N3055	.79	PN5129	.25
3055T	.69	PN5139	.25
2N3393	.30	2N5209	.25
2N3414	.25	2N6028	.35
2N3563	.40	2N6043	1.75
2N3565	.40	2N6045	1.75
PN3565	.25	MPS-A05	.25
MPS3638	.25	MPS-A06	.25
MPS3640	.25	MPS-A13	.40
PN3643	.25	MPS-A55	.25
PN3644	.25	MPU-131	.99
MPS3704	.15	TIP29	.65
MPS3706	.15	TIP31	.75
		TIP32	.79

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.15	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.29	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL

ST=SOLDERTAIL

8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW=WIREWRAP

INTERFACE

8T26	1.59
8T28	1.98
8T95	.89
8T96	.89
8T97	.89
8T98	.89
DM8131	2.95
DP8304	2.29
DS8833	2.25
DS8835	1.99
DS8836	.99
DS8837	1.65
DS8838	1.30

INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

DATA ACQ.

ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0816	14.95
ADC0817	9.95
ADC0831	8.95
DAC0800	4.49
DAC0806	1.95
DAC0808	2.95
DAC1020	8.25
DAC1021	7.95
DAC1022	5.95
MC1408L6	1.95
MC1408L8	2.95

EXAR

XR2206	3.75
XR2207	3.75
XR2208	3.75
XR2211	5.25
XR2240	3.25

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9304	.95
9316	1.00
9328	1.49
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9368	3.95
9401	9.95
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9602	1.50
9637	2.95
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AY3-8910	12.95
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OPTO-ISOLATORS

4N26	1.00	MCA-7	4.25
4N27	1.10	MCA-255	1.75
4N28	.69	IL-1	1.25
4N33	1.75	ILA-30	1.25
4N35	1.25	ILQ-74	2.75
4N37	1.25	H11C5	1.25
MCT-2	1.00	TIL-111	1.00
MCT-6	1.50	TIL-113	1.75

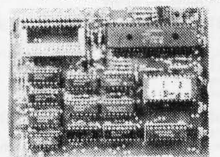
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—Roger Secura

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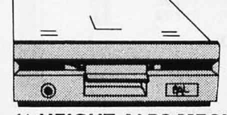
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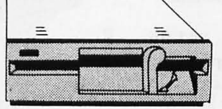
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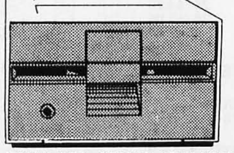
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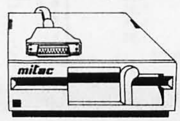
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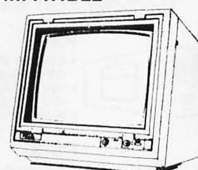
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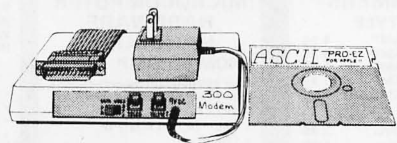


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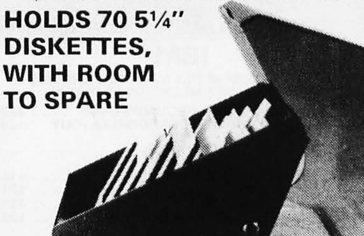
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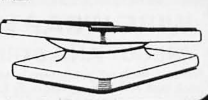
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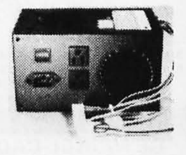
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U·N·C·L·A·S·S·I·F·I·E·D A·D·S

WANTED: Operation California, an international organization active in African famine relief, needs donation of full system for supply acquisition, monitoring use of donations, and donor lists. Operation California Inc., 7615½ Melrose Ave., Los Angeles, CA 90046, (213) 658-8876.

WANTED: Nonprofit organization for cultural support to foreign-born adopted children and moral support to parents seeks donation of computer equipment and peripherals for national office. Parents and Friends of the Nest, POB 235, West Nyack, NY 10994, (914) 358-6452.

NEEDED: Tax-deductible computers, peripherals, and public-domain software sought by nonprofit university sponsoring a volunteer group of graduating MBAs to help improve managerial skills and economic conditions in developing nations. Ron Robbins, 806 North Fourth St., Fairfield, IA 52556, (515) 472-9464.

WANTED: Nonprofit training program for developmentally disabled adults seeks tax-deductible donation of IBM PC with printer for educational and administrative purposes. Will pay shipping. John Schiermeister, Tri-City Care Inc., 15 1st St. SE, POB 423, Stanley, ND 58784, (701) 628-2990.

NEEDED: Missionary, responsible for introduction of computer system in Christian publishing organization, needs books, magazines, or information about UNIX, C, office automation, computer-assisted translation, and typesetting. Ingo Haake, POB 1688, 90000 Porto Alegre RS, Brazil.

WANTED: Nonprofit charitable organization that uses TRS-80 equipment in every aspect seeks contributions of additional equipment. Robert Epstein, Cambridge Center for Behavioral Studies, 11 Ware St., Cambridge, MA 02138, (617) 495-9020 (collect).

WANTED: Housebound child with juvenile arthritis seeks computer. Johanna Avella, 112 Denton Ave., Lynbrook, NY 11563, (516) 599-7425.

WANTED: Student in research and experimentation in computer science seeks correspondence about Macintosh or Apple IIc. Henry E. Jara Melgarejo, Las Lilas 0483, Pob. Imperial, Temuco Ixa. Region, Chile.

WANTED: Low-income older student needs Atari 800 or 800XL with disk drive and color monitor. Can pay up to $300. Conciere Taylor, Apt. 6B, 67-08 Parsons Blvd., Flushing, NY 11365.

WANTED: Graduate student seeks correspondence in microcomputer field to discuss hardware/software trends with reference to engineering/scientific applications. Also need help in obtaining magazines and public-domain software. Can provide some remuneration. Malcolm Silberman, 15 Villa Savoy, Savoy Estates, 2090, Johannesburg, South Africa.

WANTED: Public-domain dictionary (i.e., word list) good for use in word games. Also, public-domain information or software for playing crossword games from PC to PC. Will pay expense or send disk. Steven Alexander, Apt. 300, 905 Union St., Brooklyn, NY 11215.

WANTED: BYTE, December 1984. Richard Boehmer, 134 Beechwood Rd., Braintree, MA 02184.

WANTED: Tractor-feed adapter and cut-sheet feeder for Comrex CR-I ComRiter wide-carriage daisy-wheel printer. Bob Hall, 24621 Highway 29, Middletown, CA 95461.

FOR SALE: Franklin Ace 1200, 64K RAM, two drives, Z80 CPU with added 64K RAM, 80-column card, serial and parallel ports, Amdek Color I monitor, Kraft joystick, speech synthesizer, magazines, manuals, and more. Excellent condition. I will pay shipping; $2400 or best offer. Brian Gimelson, The Peddie School, Hightstown, NJ 08520.

FOR SALE: Two Siemens FDD 100-8 8-inch SS/DD floppy-disk drives. Includes power supply and enclosure. System has 9 months light usage. $200. Darrow Kirkpatrick, POB 1049, Carpinteria, CA 93013, (805) 684-8307, days.

FOR SALE: HP 41CV calculator (needs repair), 82104A card reader, XFUNCTIONS/XMEM module, XMEM module, Circuit Analysis Pac ROM, 82059B recharger, 120 magnetic cards, *High Level Math* solutions book, keyboard-overlay kit; everything as is: $150. Dwight W. Hughes, 413 East St. Andrew Ave., Forrest City, AR 72335, (501) 633-8415.

FOR SALE: Tektronix 4052A graphics computer system, 64K, communications backpack (Option 1), tapes, and manuals. Excellent condition. Well below $5950 list price. David F. Rogers, 817 Holly Drive E, Route 10, Annapolis, MD 21401, (301) 757-5724.

FOR SALE: Three Okidata 82/92 tractors unused: $20 each. NEC modems, 2400/4800 bps, good condition. Hector Saviotti, 29 Cheryl Jane Dr., Waterbury, CT 06705, (203) 753-1058, evenings or weekends.

FOR SALE: Memory upgrade board that brings 8K PET 2001 to 64K: $35. Also, Texas Instruments Silent 700 RIO thermal printer (friction feed, RS-232C, 80-column): originally $895, asking $300 or best offer. Call F. G. Volpicelli, (914) 738-1071.

NEEDED: An Insight Enterprises EQ-4 single-board computer user to solve a problem. Can pay for the help. Write to Pablo Gaggino, Arturo Bas 146, Cordoba 5000, Argentina.

FOR SALE: Tektronix dual floppy-disk unit Model 4922 with two 8-inch Memorex SS/SD drives, controller cards, and power supply in one cabinet. All manuals. Best offer or trade. John Strupat, 77 Elmwood Ave., London, Ontario N6C 1J4, Canada.

WANTED: Teacher needs nonworking Commodore printers and disk drives (1520, 1525, 1526, and 1540-1541). If donated, will pay shipping. If selling, please state lowest price. Send SASE for reply. Carl Bogardus, Chaparral Elementary School, 1220 Birch Dr., Las Cruces, NM 88001.

TRADE: TI-99/4A software written by me for your TI user-written software. Also homebrew attachments for TI, designs, ideas for software projects, etc. Craig Lewis, 2940 Callendar Rd., Rome, OH 44085.

NEEDED: Incarcerated computer science students studying toward AA degree seek typewriters and anything that may aid in rehabilitation. Robert W. Mallette III and Gerald D. Fuller, Maryland Penitentiary, 954 Forrest St., Baltimore, MD 21202.

FOR SALE: Xerox 820: $125. TVT-III: $75. 18-slot Godbout motherboard: $30. Thinker Toys ATE tape: $5. Wamco CPU-1 (8080): $50. Wamco EPM-1 ROM board (no ROM): $25. Five Wamco MEM-1 RAM boards (no RAMs): $25 each. More assorted equipment available. Warren E. Greenberg, 145 Cottage Rd., West Roxbury, MA 02132.

FOR SALE: Sharp PC-1500A pocket computer with 8K RAM. Commodore VIC-20 with 16K RAM plus Datasette. Must sell; mint condition; best offer. Peter Sutter, 4125 North Monticello, Chicago, IL 60618.

FOR SALE: Back issues of BYTE: July, August, and December 1978; February through December 1979; and January through March, and June 1980. $4 an issue. Vlad Kievsky, 5904-9 Stevens Forest Rd., Columbia, MD 21045.

FOR SALE: Digital Letterprinter Model 100-PC, high-speed, heavy-duty dot-matrix printer with tractor feed; 6 months old and hardly used; original crating, instructions, etc.: $750. Michael Bach, 2115 Frederick Ave., Kalamazoo, MI 49008, (616) 385-7074, days, or 344-8289, evenings.

WANTED: Sets of the magazines *TI 99er*, *Home Computer*, and *Personal Computer*. Will trade or sell early issues of *Kilobaud* and *Interface*. Merle Vogt, POB 145, Von Ormy, TX 78073.

FOR SALE: NEC APC-H12 color-graphics board with 128K RAM expansion memory for the NEC APC H03 color computer. New, unused, and in original box. $575 including UPS in the continental U.S. Howard D. Roney, 4840 Andrea Dr. NW, Salem, OR 97304, (503) 378-1826, after 6 p.m.

UNCLASSIFIED ADS MUST *be noncommercial, from readers who have computer equipment to buy, sell, or trade on a onetime basis. All requests for donated computer equipment must be from nonprofit organizations. Programs to be exchanged must be written by the individual or be in the public domain. Ads must be typed double-spaced, contain 50 words or less, and include full name and address. This is a free service; ads are printed as space permits.* BYTE *reserves the right to reject any unclassified ad that does not meet these criteria. When you submit your ad* (BYTE, *Unclassified Ads*, POB 372, Hancock, NH 03449), *allow at least four months for it to appear.*

FOR SALE: BYTE, May 1977 through October 1983 and a few issues before May 1977. Buyer pays shipping. Dave Lamb, 3501 Kingston Circle, Ft. Collins, CO 80525, (303) 223-7131.

FOR SALE: TI-99/4A, disk controller and drive, peripheral expansion box, extended memory card, and more. Never used. Paid $750; asking $500 or best offer. Bruce Ransom, 13278 Paramount Dr., Saratoga, CA 95070, (408) 741-1492, evenings.

FOR SALE: Micromint MPX-16 single-board computer system, MPX-17 IBM keyboard interface, and more. $900. Lee W. Sorensen, 6555 Lawndale Lane, Maple Grove, MN 55369, (612) 420-2425.

FOR SALE: ICs including eight 4116s, 68000, two 4802s, TTL, and CMOS. Also over 500 miscellaneous components including transistors, ceramic resistors, metal film and carbon resistors, diodes, and capacitors. Most new, all marked. $1000 value; asking $300 firm. T. Atiyeh, 6 Munnisunk Dr., Simsbury, CT 06070, (203) 651-0819.

FOR SALE: DEC Rainbow 100 unit with keyboard, black-and-white monitor, owner's manual, new: $1200. James Guilford, POB 15060, Cleveland, OH 44115, (216) 961-0462.

FOR SALE: TI-99/4A computer with expansion box, 32K card, RS-232C, disk drive, speech synthesizer, and more: $1000 plus shipping. Bill Stefek, 36 Sedgwick, Oswego, IL 60543, (312) 554-8256.

WANTED: *PC* Magazine, volume 1, numbers 1, 2, and 6. W. A. Winshall, 3 Ferndale Rd., Weston, MA 02193, (617) 235-5360.

FOR SALE: Breadboard interface for TRS-80 Model I/III; plugs into expansion slot and has on-board logic probe, 8-trace scope multiplexer, cables, and manuals: $250. Also, HUH TRS-80 to S-100 bus adapter: $35. U.S. postal money order only. I will pay shipping. Steve Griffith, POB B39708, Butte Ave., Florence, AZ 85232.

WANTED: Users of Timex Sinclair 1000 for correspondence and practical information sharing. Wish to form club. A. M. Bailey, c/o POB 161815, Sacramento, CA 95816-1815.

FOR SALE: North Star Horizon S-100 bus mainframe (12 slots) with Z80, two serial and two parallel ports, MS&C DMB6400 64K DRAM, SDS Versafloppy-II disk controller, cabinet and power supply with two Seimens FDD 100-8 8-inch floppy drives, Heathkit H-19 terminal, and Epson MX-80 printer: $2500. Send SASE. Richard Palmer, 72 Alda Dr., Poughkeepsie, NY 12603.

WANTED: Software driver (8080 code) for Heuristics SpeechLab Model 20S (S-100 model). The manufacturer's out of business, and the board's ROM is not working. Will pay postage, cost of disk or photocopying, etc. Bud Stolker, 101 South Whiting St. #1506, Alexandria, VA 22304, (703) 370-2242.

FOR SALE: LA34 DECwriter IV printer/terminal, mounted on matching stand (on casters) with output/input trays, complete with optional tractor, manual, cable, and ribbons, perfect condition: $450. Paul Morgenstern, 59 Vernon St., Waltham, MA 02154, (617) 894-9120.

FOR SALE: DEC Rainbow 100A with 256K, two 400K drives, monitor, keyboard, one communication port, one parallel port, all cables, and manuals. Asking $2350 or best offer. Jirayu Treraprasert, 385 North Rockvale #8, Azusa, CA 91702, (818) 334-1185.

WANTED: Atari 800XL owner would like to correspond with other Atari users to explore its capabilities and potential by exchanging information, ideas, advice, and public-domain or user-written programs. Ferit Saracoglue, MD, Gazi Mustafa Kemal Bulvari, No: 120/19, Maltepe, Ankara, Turkey.

FOR SALE: Two IMSAI VDP 80s with 64K RAM, two 8-inch disk drives. Excellent condition. Best offer. A. M. Agapos, POB 352, Dauphin Island, AL 36528, (205) 460-7171 or 861-7326.

FOR SALE: Complete set of BYTE, first issue through present. Excellent condition. Best offer. Marlene Iadavaia, Suite 410, 5725 Paradise Dr., Corte Madera, CA 94925; (415) 924-0840.

FOR SALE: Sage II computer with Qume QVT-211 GX amber graphics terminal, 500K 150-ns RAM, two low-profile 640K floppies, RS-232C port, IEE-488 port, Centronics parallel port, modem port, all manuals, and more. Originally $5700; asking $4500. Wayne Britton, 3800 McKinley, Plano, TX 75023. ■

B·O·M·B

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BOMB *Results*

PERFECT PRODUCT PREDOMINATES

In the May BYTE Jerry Pournelle took Computing at Chaos Manor "In Search of the Perfect Product." The readers gave it the blue ribbon. In second place is Gregg Williams's product description of "The AT&T UNIX PC." The continuation of Ciarcia's Circuit Cellar project on how to "Build the Home Run Control System, Part 2: The Hardware" came in third. In fourth place is "Multiprocessing: An Overview" written by Rich Krajewski. And winner of the $100 prize is Alan Finger, author of the fifth-placed review of the "IBM PC AT." Next in line is Computers and Law coauthored by Robert G. Sterne and Perry Saidman. Their study of "The Sale of Computer Products" placed sixth. Ask BYTE, conducted by Steve Ciarcia, won seventh place. In eighth place, and the winner of the $50 bonus, is Jerry Grady's review of "The Compaq Deskpro."

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Inquiry 229

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